The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

VOL. IX. PITTSBURGH, PA., MARCH, 1921 No. 3.

Electric Furnaces for Making Steel

Classification of Electric Steel Making Furnaces—General Features and Advantages of the Arc Furnace and the Resistance Furnace—Operating Features of Electric Furnaces.

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Birks Professor of Metallurgy at McGill University.

PART I.

THE electric steel furnace is a furnace heated electrically and employed for the production of steel. This type of furnace is intended as a rule for making steel from a metallic charge and not from iron ore, although it may occasionally be used for ore-smelting. The electric furnace may be used for melting steel scrap or mixtures of steel scrap and pig iron, or on the other hand it may receive molten steel that has been made in a Bessemer converter or open-hearth furnace. It may function merely as a melting furnace or it may be used for refining or purifying the material supplied.

Most electric furnaces used for steel-making are heated by means of electric arcs; these arcs being the chief means whereby the electric energy supplied to the furnace is converted into heat. In some furnaces, on the other hand, no arc is formed, and the heat is produced by the passage of the electric current through the molten steel that is being treated. Electric furnaces vary greatly in shape, size and construction, but they can be classified most satisfactory with regard to the means whereby the electrical energy is converted into heat.

Classification.

Electric steel furnaces may be divided in the first place into arc furnaces, which are heated mainly by means of one or more electric arcs, and resistance furnaces, in which no arc is employed and in which the heat is produced by passing an electric current through some solid or molten material.

Arc furnaces may be divided into "independent arc furnaces," such as the Stassano and Rennerfelt furnaces, in which the arc is struck between two or more carbon or graphite electrodes and is independent of the material of the charge, and "direct-heating arc furnaces," such as the Heroult and Girod furnaces, in which each arc is formed between one carbon electrode and the metal of the charge or its covering slag.

The independent arc furnace has the advantage that it can be operated when it is empty, which may be needed for making or repairing the furnace lining, and that a fairly steady electrical load can be maintained even when melting cold scrap. On the other hand, as the heating arc is produced between electrodes and is not in contact with the metal, the trans-

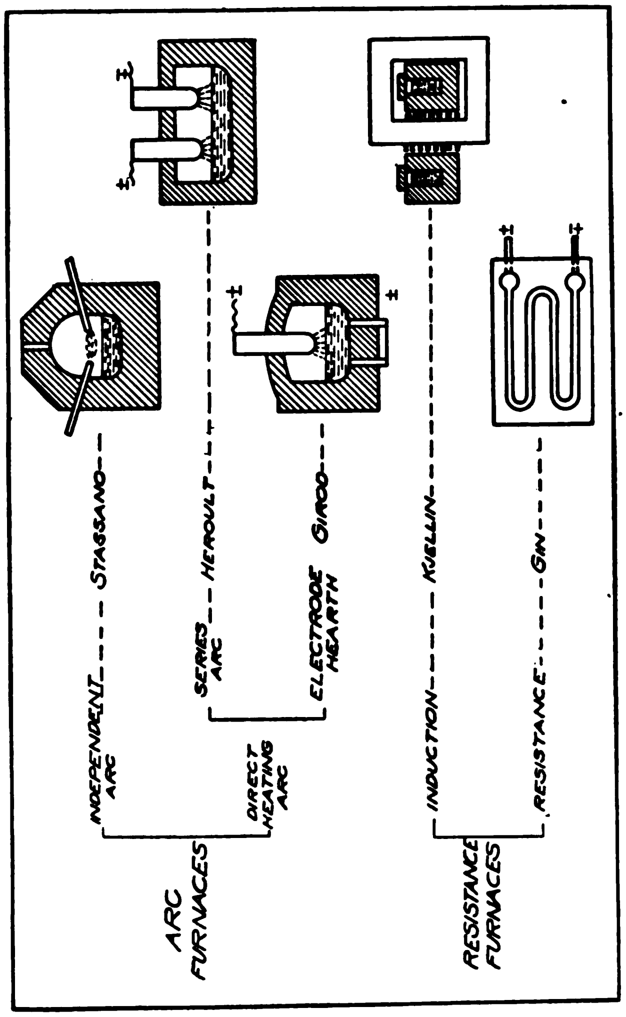

Fig. 1—Classification of electric steel-making furnaces with typical examples.

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[*] These articles form part of a book on the Electric Metallurgy of Iron and Steel to be published by the McGraw-Hill Book Company.

fer of heat to the charge is less perfect than in other types and the efficiency is consequently less; although in the Rennerfelt furnace the arc is blown magnetically against the metal to be melted, thus raising the efficiency.

In direct-heating furnaces each arc is formed between an electrode and the metallic charge in the furnace, which thus forms one pole of each electric arc. The heat is produced partly on the surface of the charge, where the arc strikes it, partly in the arc itself and partly at the tip of the electrode. When, as is usually the case, short low-voltage arcs are employed, the heat from the upper electrode, and from the arc, is largely radiated downwards and is absorbed by the metal of the charge; being held down by the electrode itself, if this is of sufficient cross-section, and prevented from escaping towards the roof of the furnace. These furnaces should consequently have a high efficiency, but they have the disadvantage that they cannot be operated when empty, some conducting material such as coke being needed to carry the current when the furnace is heated without a charge for baking a lining; moreover the electrical load is apt to be very irregular when melting a cold charge of metal.

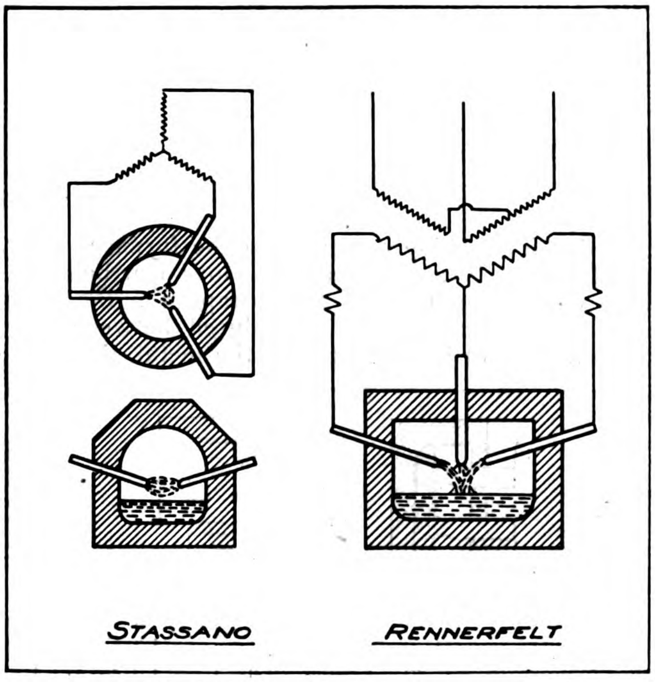

Fig. 2—Independent arc furnaces.

A further comparison may be made between these types of furnaces in respect to the temperature of the molten slag or metal. The direct-heating arc produces an extremely high local temperature beneath each arc. This effect is desirable in steel-making because it enables sulphur to be eliminated more completely, while for certain other operations, such as brass-melting, the high local temperature would be very objectionable, as it would lead to excessive volatilization of the metals forming the alloy. In the Rennerfelt furnace, although the arc is not direct-heating, an electro-magnetic flame is directed against the molten contents of the furnace and a fairly high slag-temperature can thus be obtained.

Some writers limit the term arc furnace to the class of "independent arc furnaces" in which the arc is formed between carbon electrodes, and employ the term resistance arc furnace for the class of "direct-heating arc furnaces," because in them the electric current passes through the molten metal and slag, as well as through the arc, and there is therefor a certain amount of resistance heating. The molten metal between the arcs in a Heroult furnace has a very small electrical resistance, and in consequence the heat produced in it by the passage of the current must be very small in comparison with the heat produced in the arcs, although an appreciable amount of heat will, no doubt, be produced by the passage of the electric current through the layer of slag. It appears to the writer that the fact of the arc being formed directly on the metal to be heated, which is indicated by the term "direct-heating," has a far more important effect on the operation of the furnace than the resistance effect of the metal in the charge.

Direct-heating arc furnaces may themselves be divided into series-arc furnaces—such as the Heroult furnace, Fig. 1, in which two arcs are operated in series and in which no electrical contact need be made to the hearth of the furnace, and electrode-hearth furnaces such as the Girod furnace, Fig. 1, in which the hearth of the furnace constitutes one electrode, and the arcs, if there are more than one, are not operated in series.

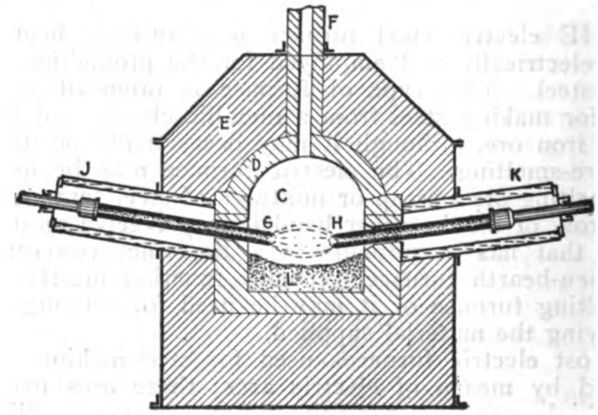

Fig 3—Stassano furnace—stationary.

Series-arc furnaces, of which the Heroult is the best known example, have the following principal advantages:

1. As two arcs are connected electrically in series the furnace can be operated at a high voltage without the use of long arcs. Electrical power can be supplied to furnaces more cheaply and efficiently at a high voltage than at a low voltage, and short arcs in general more efficient than long arcs because the heat is produced in closer contact with the metal to be heated.

2. The absence of any electrical contact through the furnace bottom makes the latter easier to repair and less likely to be destroyed by over-heating.

Electrode-hearth furnaces were originally represented by the Girod furnace, Fig. 1, and the Keller furnace, but in recent years a large number of furnaces of this type have been developed, including the electro-metals, the Snyder, and the Greaves-Etchells. Some of these, such as the smaller forms of the Girod, Keller and Snyder furnaces, are especially simple in construction, having only one movable electrode, and being heated by a single arc; in larger forms of the Girod furnace, two or more arcs are produced and an equal number of movable electrodes are needed, but the electrodes are all connected to-

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gether and the arcs are operated in parallel. The more recent furnaces of the electro metals, Greaves-Etchells and Snyder variety use two-phase or three-phase current with a common return to the base of the furnace.

Electrode-hearth furnaces offer the following general advantages compared with series-arc furnaces:

1. In the series-arc furnace, using single-phase current, if one arc should break, the other arc is necessarily interrupted, and contact with the charge must be re-established with both movable electrodes, or with two electrodes in a three-phase furnace, before either arc can be started. In the electrode-hearth furnace, the arcs, if there are more than one, are independent of each other, and each arc can be started again by moving a single electrode.

2. As the electric current flows through the furnace hearth it will produce heat in the hearth itself and in the lower portion of the metal bath, while in some cases an electrical circulation is produced which stir up the molten metal and keeps it mixed.

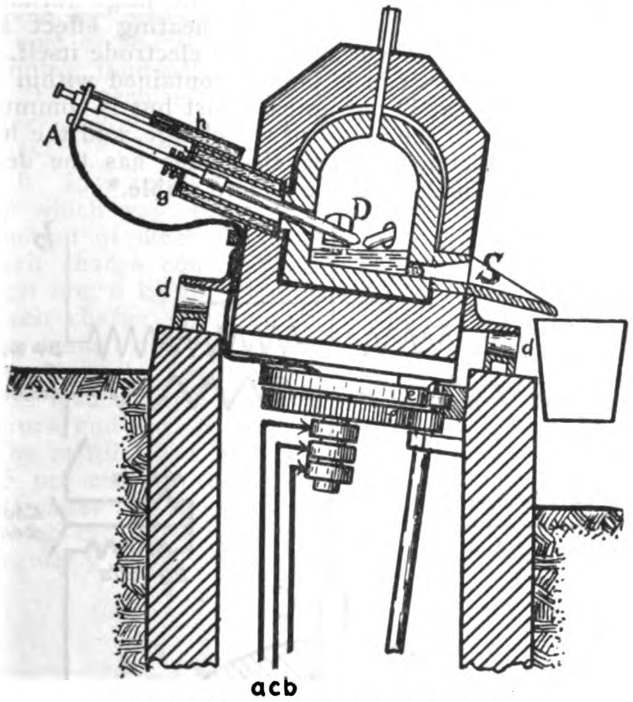

Fig. 4—Stassano furnace—revolving.

3. Although in general the electrode-hearth furnace has a lower voltage, because only one arc is operated in series, yet in one variety, the Snyder furnace, a high voltage is employed with the aid of an electrical steadying device. The high voltage enables a very long electric arc to be maintained, and this renders easier the melting of cold scrap, as the long arc is less easily broken than a short one, and produces a more uniform heat throughout the furnace.

Resistance furnaces are usually operated without electrodes, the electric current being generated inductively in the metal of the charge. Such furnaces, of which the Kjellin and the Northrup are examples, may be termed induction transformer furnaces. A few furnaces, such as the earlier form of the Gin furnace, Fig. 1, and the Hering furnace, employ electrodes and separate transformers, and these are termed resistance furnaces.

The electrical resistance of a mass of molten steel is so small that an enormous current at a very low voltage must be used for heating it, and as such a current cannot be led into a furnace by means of electrodes, without very heavy losses, it is usual to operate resistance furnaces on the induction of transformer principle which enables electrodes to be dispensed with.

In some resistance furnaces, chiefly of small size, such as the Helberger furnace, the resisting element is not the steel itself but a crucible, consisting in part of graphite, which contains the steel and is itself heated by the passage of the current. This type of electric furnace can scarcely be used for steel melting except on a small scale.

The classification of electric steel-furnaces can be understood very readily by reference to Fig 1.

Independent-Arc Furnaces.

In this class of furnace the arc is maintained between the ends of two or more movable electrodes which are made of carbon or graphite. This construction renders the arc independent of the material forming the charge, and the furnace can be heated equally as well when it is empty as when it contains a charge of metal. On the other hand, as the contents of the furnace are heated by radiation from the arc, this type of furnace is likely to be less efficient than the direct-heating arc furnace in which the metal to be heated forms one pole of each arc. There are two important examples of this class: the Stassano, which is heated by a three-phase arc between the ends of three nearly horizontal electrodes, and the Rennerfelt, which employs a two-phase arc between three electrodes. The Rennerfelt furnace has the advantage that the arc is forced downwards, like a blow-pipe flame, and so heats the contents of the furnace more rapidly. This feature is not claimed for the Stassano furnace but if the electrodes are inclined to the horizontal there will tend to be a downward motion of the arc. The electrical arrangement of these furnaces is shown diagramatically in Fig 2.

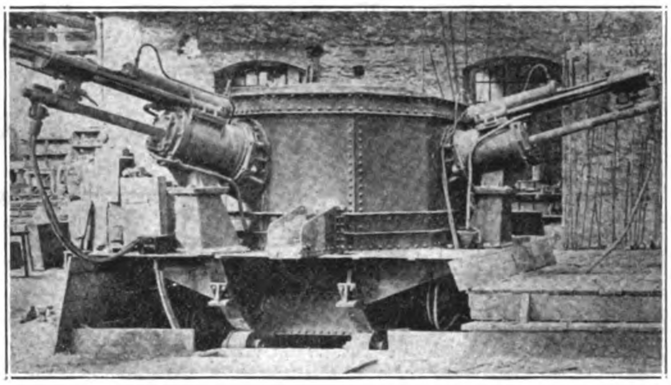

Fig 5—Stassano furnace—tilting.

Stassano Furnace.

This furnace was devised by Captain Stassano for the purpose of smelting iron ore. After a number of experimental designs, he arrived, about the year 1902, at the form shown in Fig. 3. This consists essentially of a refractory chamber, of about one meter internal diameter, lined with magnesite bricks, and provided with two lateral electrodes for simple-phase current. The electrode holders are contained within water-cooled chambers, which enable the furnace to be almost air-tight, and the electrodes can

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be adjusted by means of hydraulic cylinders. The furnace was sometimes stationary, as in Fig. 3, but usually it was made to rotate, see Fig. 4, and as it was mounted at an angle to the vertical the rotation had the effect of stirring up the contents of the furnace. The materials of the charge are introduced through the door D and the molten steel is allowed to flow out by the tapping hole and spout S. When employed for ore-smelting the crushed ore was mixed with charcoal and flux and was briquetted before being charged into the furnace. The heat of the furnace caused the ore to react with the charcoal, thus producing metallic iron. This was melted and finally tapped out as steel of any desired composition. The furnace operated satisfactorily and produced steel of excellent quality, but the cost was too high and the smelting of iron ore in this type of furnace was abandoned. The furnace has remained in use in Italy and elsewhere for making steel from a metallic charge.

The rotation of the furnace rendered more difficult the supply of electric power and cooling water, and, with a view to simplicity and cheapness of construction, a more recent form of the furnace is arranged to tilt instead of revolving. A photograph of this form is shown in Fig. 5, which represents a furnace in use in Germany before the war. Another form which was installed in California[6] is mounted like a ship's compass, and by means of gearing it is made to oscillate slowly to stir the charge, as shown in Fig. 6.

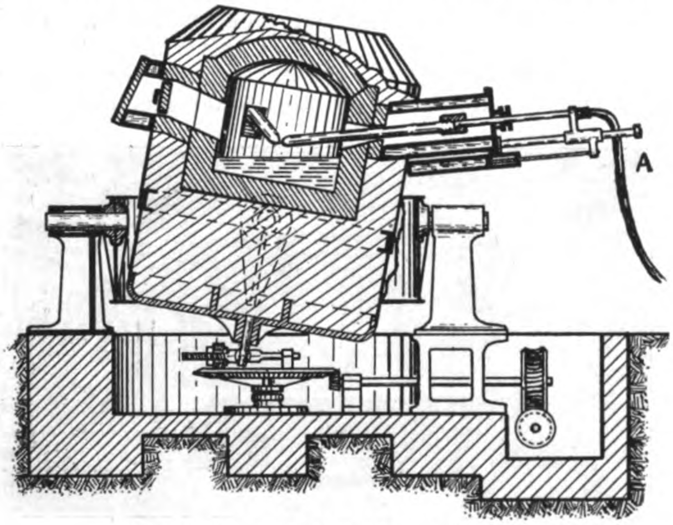

Fig. 6—Stassano furnace—oscillating.

The Stassano furnace uses single phase or three-phase current at a voltage of from 75 to 150 volts, according to size. The current varies from about 1,000 to 3,000 amperes per electrode, the power-factor is high, usually 90 or 95 per cent, and the electrical load is very steady, seldom varying more than 10 per cent above or below the average. The electrodes are of amorphous carbon and vary from about 3 inches to 6 inches in diameter; they are made in lengths of 5 feet and are used until only about 6 inches remains, when the furnace is stopped for a few minutes and a new electrode is introduced. The consumption of electrodes is about 20 pounds per ton of steel, costing about 80 cents. One man is needed to regulate the electrodes of each furnace as automatic regulators are not employed. The electrodes, in a vertical furnace, having an inclination of about 1 in 6, which serves to bring the arc nearer to the melted steel without danger of the slag getting into the electrode openings. The inclination of the electrodes has also an electro-magnetic effect tending to depress the arc (see discussion under Rennerfelt furnace) which would otherwise tend to rise in the furnace on account of its high temperature. The arc in the Stassano furnace is actually bent slightly downward, and when the charge is high in the furnace, the arc passed down from each electrode to the slag and metal as in a Heroult furnace. Owing to the construction of the furnace this condition cannot be brought about at will as in the recent forms of the Rennerfelt furnace.

The high voltage (150 volts for a 1,000 hp furnace) at which Stassano's furnace operates, gives a high electrical efficiency, because the electrical losses in transformers, cables and electrodes are less than in a furnace using a lower voltage. The electrodes themselves are operated at a high current-density, 100 amperes per square inch in the large furnaces, and this entails a considerable heating effect and consequent drop of voltage in the electrode itself. As however the electrode is mostly contained within the furnace this heat is not entirely lost but is communicated in part to the metal of the charge, and the high electrical resistance of the electrodes has the desirable effect of making the arc more stable.*

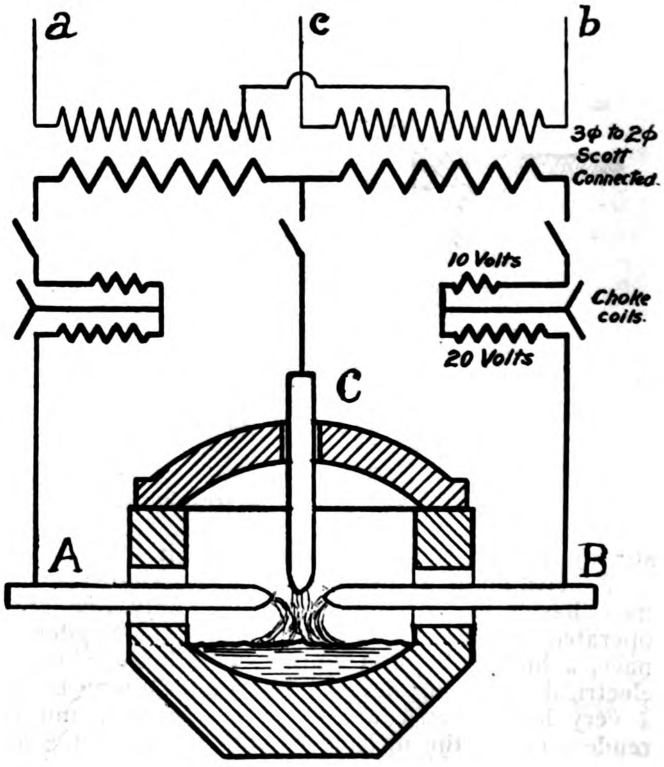

Fig. 7.

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*A six-inch electrode 5 feet long, carrying 2,700 amperes, has a current-density of 100 amperes per square inch and an electrical resistance of 0.003 ohm. It would cause a drop of 8 volts and a heat-production of 23 kw. The heat produced in the three electrodes would amount to 70 kw. or 10 per cent of the power supply. The diameter of a 5-foot electrode, carrying 2,700 amperes and heated at one end to 3,700 degrees C., should be 8½ inches according to Hering's formula or twice the cross-section actually employed. As, however, the electrode is mostly contained within the furnace this heat is not entirely lost but is communicated in part to the metal in charge, and the high electrical resistance of the electrodes has the desirable effect of making the arc more stable.

The Stassano furnace, having an independent arc, can be operated easily, and with a steady load, whether it is empty or contains a charge, and even when melting cold scrap. The heat of the arc, however, spreads generally throughout the furnace, instead of being given directly to the charge as in the direct-heating arc furnaces, and in consequence the thermal efficiency is not very high and the roof of the furnace needs frequent renewal. The thermal efficiency is improved by the thick walls and roof of this furnace, but this feature shortens the life of the roof, which is said to last only one week[12] and the cost of refractories, before the war, was over $2.00 per ton of steel.

Furnaces have been made of three sizes, small single-phase furnace of 100 hp and three-phase furnaces of 200 hp and 1,000 hp. The 200 hp furnaces hold about 650 kg of steel (two-thirds of a ton), while the 1,000 hp furnace held 4,000 kg, or four tons of steel. The cost of a 1,000 hp furnace is given by Stassano[1] as $5,000, while Osann[9] quotes a cost of $8,750 for a one-ton furnace (250 hp), including foundation and switchboard.

The performance of the Stassano furnace as a steel melter may be gathered from the following data:

1. In a small furnace of 600 kg capacity and 200 hp which was operated at Turin in 1905 for the production of steel shells for the Italian Government[8] each charge contained 150 kg of cast iron, 29 kg iron ore, 6 kg lime and about 450 kg of steel scrap. Each charge required about 850 kw hours, including transformer losses, or about 1,400 kw hours per ton of steel. Two thousand five hundred kg of steel was made daily so that each heat required about six hours and the power supplied was about 150 kw. The melting loss was not over 2 per cent even when 75 per cent of the charge was turnings. Stassano estimates the efficiency of the furnace at 15 per cent, which can hardly be accurate because steel scrap is regularly melted in modern furnaces with twice the efficiency that was obtained in this small furnace.

2. In a later report of the 200 hp furnace at the Royal Artillery Works[5], the furnace was employed to melt and refine steel scrap, and the consumption of power amounted to 1,250 kw hours per metric ton of steel.

3. A 200 hp furnace at Stassano's plant in Turin, mentioned in the same report, was making low-carbon steel from a charge of steel scrap and pig-iron, with a consumption of 1,260 kw hours per ton.

4. A furnace of 1,000 hp, at the same plant, made shell-steel from charges of steel scrap and pig-iron with a consumption of 920-960 kw hours per metric ton.

5. The oscillating furnace installed in 1913 at Redonto, California, had a capacity of 2,000 pounds and a power of about 200 hp. A charge, consisting mostly of steel scrap, required about five hours to melt and finish with a consumption of about 1,000 kw hours per net ton.

The furnaces at the works of the Stassano Electric Furnace Company at Turin, about the year 1908, were as follows:

Two 100 hp single-phase taking 1,000 amps., at 75 volts.
Two 200 hp three-phase taking 900 amps., at 100 volts.
Two 1,000 hp three-phase taking 2,700 amps., at 150 volts.

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(Continued in April issue)

Gases Obtained in Molten Steel

Dealing With the Gases Which Manifest Themselves During Steel Making Operations—Classification of the Gases and How to Deal With Them in Order to Make the Product Sound.

By HENRY D. HIBBARD.

PART III.

THE genesis of skin holes when present in would-be effervescing steel is probably as follows: Let us consider first the extreme case where these holes infect the whole ingot surface as thickly as possible. In the melting furnace such steel boils too mildly because of too high a temperature or not enough oxygen (ore), one or both, and as a consequence it contains more hydrogen gas than it should; as with a more vigorous boil the escaping CO bubbles would have carried more of it off. In the mold therefore the point of saturation of hydrogen in the metal is quickly passed as the steel cools and the gas begins to separate, forming at first small bubbles which adhere to the solidifying walls. In the extreme case we are considering there is no escape of gas in the mold which would, if plentiful enough, have an important effect in preventing skinholes. The hydrogen bubbles grow by accretions of gas from the cooling steel while the metal between them gradually freezes, forming the thin separately partitions. The bubbles grow naturally in the direction of the least resistance, which is toward the center of the ingot. Hence their elongated shapes and axes normal to the cooling surface. They continue to grow as fast as the ingot wall solidifies until at some certain depth they all cease growing. The reason why they thus cease does not appear, but that is of no practical moment to the

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steel maker, as the steel is irretrievably bad. If the boil in the furnace has been more active, so as to be but partially inadequate, the hydrogen content of the metal will be less than in the extreme case described and the saturation point will not be reached in cooling until a skin of solid steel of some thickness has been formed say from ¼ to 1.2-inch thick. A zone of smaller and more nearly spherical bubbles will then be formed which may not be particularly harmful if their outer skin be not burned through in the heating furnace. There will be some effervescence due to the escape of CO in the mold, but the steel will rise to the extent of the collective volume of the diminished skin holes. In other cases of insufficient effervescence, relatively few and small skin holes will occur, and often in clusters or groups which nevertheless are enough to condemn the part of a plate containing them to the scrap heap. When the boil in the furnace is active enough the hydrogen content is cut down on an allowable amount. The effervescence in the mold is brisk. Hydrogen bubbles do not begin to separate until perhaps ¾-inch of solid steel has formed and then such as do form are dislodged and swept away by the rising bubbles and the currents of metal they cause. A few around the bottom where the evolution of gas is less copious may escape such action and remain but they will not do much harm.

The second variety under Class III are the intermediate holes (sometimes called deep-seated holes), and they occur in effervescing low carbon steel in a zone between the surface and the center of the ingot from one to three inches from the surface, depending on the size of the ingot and the efficiency of the effervescence. They are more nearly spherical in shape than any of the other gas holes. As already stated, these holes are thought to be made by carbonic oxide. Some of the last of that gas to be expelled from the mushy central metal is mechanically held in bubbles against the already frozen wall, while the remainder is still able to rise to the surface and escape. Where there is no effervescence, as in the case of excessively high casting, temperature and as a consequence a profusion of skin holes there are no intermediate holes. As already stated in this case the CO in the liquid steel seems to be decomposed by the added manganese because of the unduly high temperature.

The third variety under Class III are the gases which form the central holes which are scattered at random in the central part of the ingot, the part which becomes mushy just before final solidification in effervescing steel. These are manifestly caused by a different gas from that which causes the skin and intermediate holes, and as ammonia is a normal constituent of gases in the central part of a steel ingot it is presumable that that gas, together perhaps with some nitrogen and, it may be some residual CO, causes and fills the central holes. These holes are not important nor harmful. Central holes are not exactly alike in their modes of occurrence in both effervescing and partly killed steels. In the former they are spread at random over a larger part of the section of the ingot, while in the latter they are located near the pipe cavity in the upper central part of the ingot. With a profusion of skin holes the central holes are few in number or even absent which indicates that CO may be a normal constituent of the gases they contain. Sections and analyses of partly killed rail ingots have shown that central holes in such steel accompany marked segregation of carbon and phosphorus in the upper central part where the holes were most plentiful. Without one of these the other did not appear. These ingots when containing about 0.12 per cent of silicon usually have a belt of skin holes around their upper half or quarter, presumably formed by hydrogen, and a cluster of central holes around the central pipe and settle holes. Intermediate CO holes are usually absent. Such steel does not rise in the molds. The silicon added seems to decompose the CO and, together with a ferrostatic pressure of four or five pounds to the square inch to hold the hydrogen in solution so that the lower half or three-quarters of the ingot is sound. In the upper part of the ingot where the pressure due to the metal head is less, some hydrogen is released from solution to form skin holes. More silicon, aluminum or titanium added would keep the hydrogen dissolved in the metal and, of course, give a larger pipe. This partly killed steel may have been cast at a proper temperature, its gas holes being the natural result of the practice by which it was manufactured.

The pipe cavity of an ingot, if airtight, probably always contains inflammable gas and under pressure which shows that it has collected in part at least in the hole after the steel solidified and while it was cooling as otherwise a partial vacuum would exist in the cavity. Talbot found the part of this gas insoluble in water to be about 90 per cent hydrogen and the remainder mostly nitrogen, within one case 5 per cent of CO when the top of a large ingot of solution steel 10 tons or more in weight, is broken off by deep grooving in a lathe followed by a heavy blow, the gas in the pipe cavity thus released is often ignited by sparks caused by friction of the separated parts and burns with a slightly luminous flash of flame.

Fourth of Class III are nitrogen bubbles, which are the remains of air bubbles mechanically entangled in freezing steel. These are rare in ingots, but sometimes exist in castings. The oxygen which accompanied the nitrogen exists as CO in the hole, also as it is insoluble in the metal. These air bubbles are located at random, due to the way the air entered the metal. They can only occur in an ingot which was cast too cool or they would have risen to the top when carried under by the stream. Such an ingot would probably have wrinkles and cold shuts anyway which would without the air bubbles send it to the scrap heap. In castings, such bubbles may occur from air entrapped in a too impervious mold.

Fifth are hydrogen and CO holes, which are caused by steam bubbles which in some way have got into the steel and been decomposed by the carbon. They occur only in castings, the steam forming in the sand beneath and rising into the still liquid metal and being entrapped there. They are likely to be found, if at all, where some recess on the lower side catches the steam, and in castings made in green sand which, of course, contains considerable water.

Sixth are holes formed by bubbles of hydrocarbon gases, which result from the destructive distillation of organic matter in the molding sand by the heat of the metal. These gases get into steel castings sometimes when the mold is not properly vented and when the design of the casting is such that a pocket or recess exists on its under side, as in the fifth variety mentioned above. The heavier hydrocarbon gases may be chemically cracked by the heat, the liberated carbon entering the metal leaving only light gases in the hole.

The gases of the fourth, fifth and sixth varieties of Class III may make defects of almost any shape, as well as bubbles, which defects may be open to the air. They are the gases which sometimes make real blowholes. When they form gas holes within the metal a partial vacuum exists in each hole due to the high temperature followed by cooling.

Holes of the first three varieties probably grow in size from their first beginnings in the solid or near-solid steel until the strength of the metal has become great enough to resist the pressure of the separating gases and so prevent their further growth. The exudation of gas into them may continue, however, until a pressure is reached in each sufficient to prevent further escape of gas into it. This, as we have seen, may take place at a pressure of 600 pounds per square inch.

The intermediate and central holes form in plastic metal of rather uniform consistency, cooling at a nearly uniform rate in all directions. They are, generally speaking, more nearly spherical in shape than are the skin holes.

The occurrence of ammonia in steel was first brought to my attention nearly 40 years ago by a mechanic who regularly rough-turned large steel forgings, mostly shafts, who asked me why we put hartshorn in our steel. Full of skepticism, I questioned him about it, and he maintained that he often smelt it coming from the steel, which was Siemens-Martin steel melted in a 10-ton acid furnace by the pig-and-scrap variation. The bath was formed of pig iron and steel scrap, charcoal direct iron blooms being added hot to work out and dilute the carbon. No ore was used. The slag was usually viteous, of olive green color, when in a thin cold layer. He promised to send for me the next time he noticed heartshorn, and soon after did so, and I distinctly smelt ammonia gas coming from the center on the end of the forging. He further said that the escape of ammonia showed that there was a hole in the forging and that proved to be the fact when the knob left on the end of the rough-turning operation and containing the "center" was broken off with a sledge to permit recentering. This hole was a small, ragged pipe, probably due to or increased by forging with a too-light hammer. A fine wire could be run in about two inches and the cavity doubtless ran in much deeper. The machine-shop foreman further told me that he had had one case where the hartshorn gas escaped with an audible hissing sound with force enough to blow chips off the centering drill and in quantity to bring water to the eyes of the men nearby. I have since then met a number of men who knew of ammonia in steel, and several years ago Wickhorst noticed it in some Bessemer rail steel ingots which were split in two longitudinally, stating that "when broken these ingots gave off the odor of ammonia from the fracture and also turned phenolphthalein red." This change of color is due to alkaline reaction. Each ingot had an imperfect pipe and a number of central gas holes which were doubtless filled for the most part with ammonia.

Steel, which has been subjected to abnormal treatment, may contain holes not readily classified. Thus a heat of electric steel which, through an oversight was kept molten and extremely hot over night, made unsound ingots having gas holes which ran through the metal like worm holes through wood and were not to be recognized as any familiar kind.

Gases Which Remain Dissolved in Cold Solid Steel.

Some investigators have thought that they detected some effect from hydrogen or from nitrogen contained in steel, but the cases can hardly be considered as proven. Any hydrogen in the metal must probably be present in solution and in extremely small proportion by weight. Any nitrogen present is either in solution or combined with iron. Both these gases if present in elementary form must evidently be set free when the metal is dissolved as by an acid, but Prof. E. D. Cambell's results do not indicate any notable volume of either. The way in which silicon alluminum and titanium holds hydrogen from forming bubbles in solution steel, and from reappearing when the steel is dissolved, remains unexplained. This is, of course, assuming that Prof. Cambell tried solution steels.

Gases Which Are Evolved from Heated But Not Molten Steel.

A number of investigators have extracted gases from steel by heating it in a vacuum and have analyzed them. They were chiefly carbonic oxide and hydrogen and the quantities were from 6 to 13 volumes of the steel. The CO must seemingly be formed as it appears by the combination of carbon with oxygen in the metal and the hydrogen be released from weak combination or solution by taking away atmospheric pressure. Cast iron yielded much less gas than steel, under two volumes, which agrees with, though it does not explain the gas-dissolving power of the blast furnace ferrosilicon previously mentioned. The study of these gases does not aid the metallurgist much as his treatment of and trouble from gases all happen while the steel is fluid or nearly so.

Gases Which Are Evolved When Steel Is Dissolved.

Prof. Campbell, as already stated, has opened up this field of research which is full of interest and promises, when more fully explored to throw much light on the constitution and gases of steel. He found that one grain of pure iron evolved 400 cc of hydrogen when dissolved in acid, that being the theoretical amount. Ordinary simple steels yielded from 360 to 390 cc of mixed steel to pure iron the greater the volume of gas. One grain of pure carbide of iron yielded from 250 to 253 cc of a mixture of hydrogen and a large number of hydrocarbons. Hardened steel gives more gas than unhardened, the hydrocarbons evolved being lighter and therefore more voluminous. He found that lower mean molecular weight of hydrocarbons evolved results from:

1. Higher carbon in the steel.
2. Higher degree of hardening impaired to the steel.

His results indicate that the amounts of hydrogen, carbonic oxide and nitrogen in solution in the steels examined were very small if indeed any were present, assuming that they would have been set free when the steel was dissolved.

The effect of exposing heated steel to hydrogen, ammonia, carbonic acid and nitrogen have been tried but without results.

(Continued on page 197.)

The Manufacture of Wire Rope

A General Description of the Machines and Operations Involved in the Manufacture of Wire Rope at the Palmer Plant of the Wickwire Spencer Steel Corporation.

By CARL KING,

Wickwire-Spencer Steel Corporation.

WIRE ROPE is made by twisting into strands and then twisting the strands into rope. The machines which twist the wires into strands are called stranding machines and the machines which twist the strands into rope are called layers. The size of the machines depends upon the size of the rope.

The wire as it comes from the testing room or stock room is first spooled upon steel spools of from four to five hundred pounds capacity. This is done in order that the machines may not have to be stopped too often to braze the wires together as well as for reason that it is necessary for the wire to be placed in the machine in such a position that it may be drawn out easily and evenly.

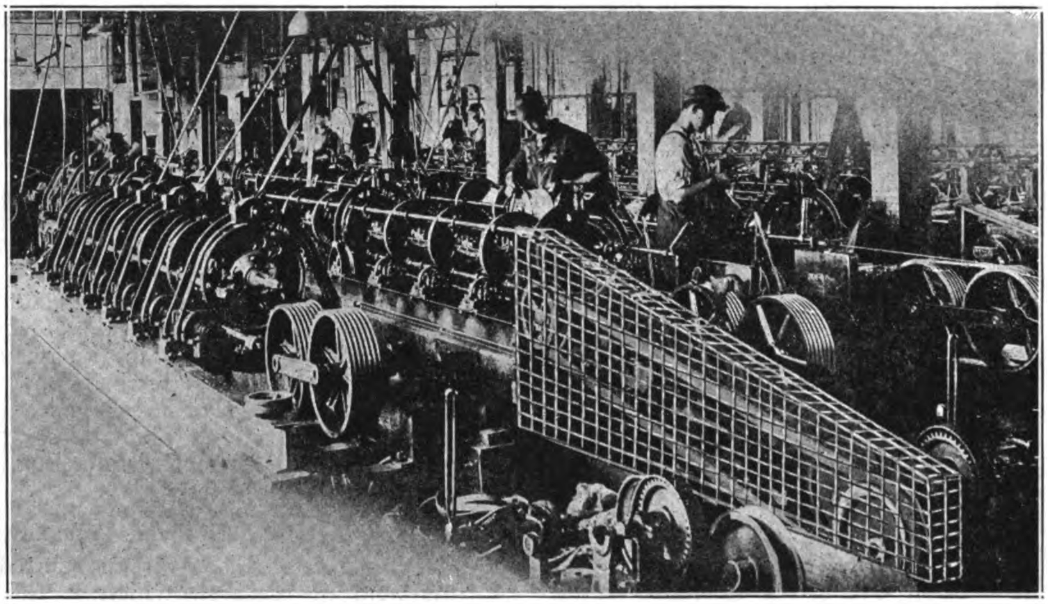

Fig. 1—Stranding machine.

Figure 1 shows a group of stranding machines. The man on the second machine is placing a full spool of wire in the cradle of the machine. The cradle, which is suspended between the discs of the machine, holds the spool and allows the wire to be drawn out evenly under a steady tension produced by a cord running over a groove in the spool.

The stranding machines shown in figure 1 are of the Smith, or English type. In these machines the wires run from the spool through the disc and from here to a sheave on one of the pipes on the machine. These pipes keep the discs the correct distance apart and the whole machine is tied together by rods running through the pipes. The wire runs along the pipe until it gets to the front of the machine, here it passes over another sheave and goes to the head of the machine.

The twisting head of the machine contains as many slots and holes as there are wires in the strand. There is always one center wire which goes through the center of the head. This wire runs straight in the strand and as the machine revolves the outer wires are twisted around the center wire.

The speed of the machine depends upon the size of the machine which, in turn, depends upon the size of the wire in the machine.

The wires, after being twisted in the head of the machine, pass around two drums which are geared to the machine. These drums are plainly shown in the foreground of figure 1. The machine runs at a constant speed and the speed of the drums can be changed to suit the size of the strand. The "lay" of the strand, which is the length of strand pulled out in one revolution of the machine, is determined by the change gears used in the train of gears connecting the machine and drums. The faster the drums revolve the greater will be the lay.

The strand, after passing around the drums several times to prevent slipping, passes to a large steel spool, which is driven by a friction drive with enough tension to keep the strand tight upon the drums of the stranding machine.

Another machine used is a large planetary machine. This machine derives its name from the motion in the back which keeps all the cradles in a horizontal position, thus preventing the wire from being twisted. The head and drums of this machine

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From Triangle Clan.

are the same as those of the Smith, or English type of machine.

The machine shown in figure 3, is a vertical layer. The strands which are made in the stranding machine are "laid up" in this machine. The principle of this machine is the same as the planetary machine, except that it is a vertical machine instead of a horizontal machine. It has eight large spools, all eight of which are used in making an extra flexible hoisting rope. For a regular hoisting rope of six strands, only six spools are put into the machine.

The six or eight strands which are laid up in this machine are laid around a manilla center. This manilla center acts as a cushion for the strands. This center is lubricated as well as the strands.

The simplest rope to make is the 6 x 7 construction. This rope is used for haulers, sand lines and standing or guy rope. As there are only forty-two (42) wires in the rope, the rope is stiff and is not easily bent around sheaves unless of very large diameter. This construction is always used to guy up derricks; and when exposed to the weather is galvanized. Figures 6 and 7 show a rope of this construction.

The rope most used as a hoisting rope is the 6 x 19 construction shown in figures 4 and 5. There are 114 wires in the rope and it is consequently much more flexible than the 6 x 7 construction rope of the same size, due to the smaller wire. Since the wires are smaller it is possible to use the rope on much smaller sheaves than a rope of the 6 x 7 construction.

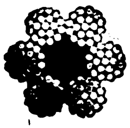
FIG. 4

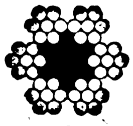
FIG. 6

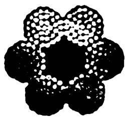
FIG. 8

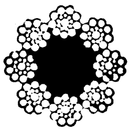
FIG. 10

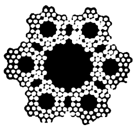
FIG. 12

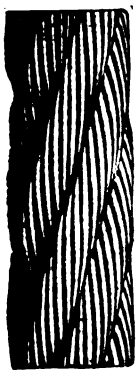
FIG. 5

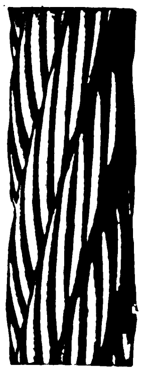
FIG. 7

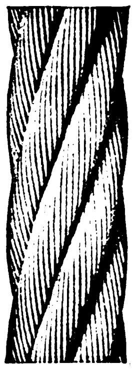
FIG. 9

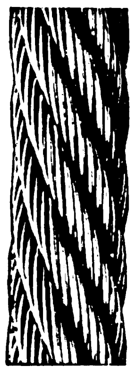
FIG. 11

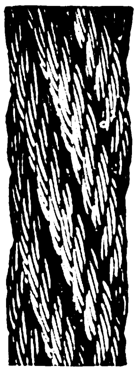
FIG. 13

For ropes which must be used on small sheaves, such as crane ropes, the 6 x 37 construction shown in figures 8 and 9 will give good satisfaction. These ropes are made of small wires and will therefore stand but little abrasion. This is called special flexible hoisting rope.

Extra flexible hoisting rope composed of eight strands of 19 wires each is about as flexible as the special flexible rope, but is not as strong. This decrease in strength is due to the larger hemp center.

Another construction, shown in figures 12 and 13, used for hand ropes on elevators and other places where the most flexible rope is required, is called tiller rope. This rope is made by taking six small ropes 6 x 7 and laying them up once more in a 6 x 6 x7 rope. The wires in this rope are very fine; the indivilual wires in a one-fourth diameter tiller rope being only .009 inch.

There are various other constructions for different purposes, but the above are the most common constructions.

Figures 10 and 11 show the construction of a 6 x 19 Seale style rope. This rope differs from the 6 x 19 shown in figures 4 and 5, in that although it has 19 wires in the strand, the outside wires are larger than the other nine wires yet they are not as large as the center wire. This construction is used on the Pacific Coast much more extensively than in the East.

Most hoisting rope today of the 6 x 19 construction is made of three sizes of wires. This allows about 10 per cent more material in the rope with the corresponding increase in strength. This type of rope is sometimes called "Warrington Lay."

Wire rope is made from wire of various kinds. The greater part of the rope is made at Palmer plant, Wickwire Spencer Steel Company, is made from steel of a tensile strength of from 180,000 pounds per square inch to 260,000 pounds per square inch. Every coil of this wire is tested on both ends and if it is not up to the required standard, it is rejected.

For guy rope, running rope and hawsers, the wire is galvanized.

GASES OBTAINED IN MOLTEN STEEL.

(Continued from page 195)

The work of the different investigators of the subject cannot be correlated partly because necessary particulars of the steels worked upon are not given.

Conclusions:

The most harmful gas holes in steel are the skin holes, which are caused by hydrogen.

Silicon, alumnium and titanium have power to keep hydrogen in solution in steel when it freezes.

Silicon aluminum and perhaps titanium have power to decompose carbonic oxide at ordinary steel casting temperatures.

Carbonic oxide is either evolved or in gas holes or is decomposed by the final additions.

Manganese has power to decompose carbonic oxide at an unduly high casting temperature.

Manganese has little or no power to keep hydrogen in solution.

Gases are probably of but little importance in cold steel except when they form gas holes or other structural deffects.

WILL REBUILD TWO STACKS.

Plans have been completed by the Wheeling Steel Corporation for rebuilding and remodeling its No. 1 La Belle stack, Steubenville, O., and its Martins Ferry stack at Martins Ferry, O. Improvements at the La Belle furnace will include the enlargement of the stack for increased capacity, relining the hot blast stoves and the installation of a new gas cleaning system complete with new uptakes, downcomers, a dust catcher and a gas washer of the Brassert type.

Direct Recovery Process for Flue Dust

Blast Furnaces Find This Process to Be One of the Most Economical—First Cost of a Direct Recovery Plant Smaller Than That of Any Other Process—Operating Expense Also Very Low.

By GEORGE B. CRAMP,
Engineering Department, Carnegie Steel Company, Clairton Works.

WITH a plentiful water supply available, other considerations in connection with the installation of a wet washing system for cleaning blast furnace gas, and incidentally a flue dust recovery system, are:

First—Dry dust catchers for receiving and holding the heavier dust particles such as are carried by the gas from the furnace under normal working conditions, and also the bulkier coke, ore and limestone stock thrown from the furnace during a slip.

Second—Wet gas scrubbers, or washers for washing out of the gas all dust remaining therein after having passed through the dry dust catcher.

Third—Disposal of the dirty wash water from the gas washers or other apparatus in which the water has been used in any manner to wash dust from the gas.

Fourth—Recovery and treatment of the wet dust from the wash water, along with the flue dust recovered in a dry state from the dry dust catchers.

Fifth—Method to be used in recharging the recovered flue dust into the blast furnace.

Consideration of the foregoing will be taken up in their respective order in that part of the discussion immediately following, with a view to outlining present practice on the subjects involved, pointing out imperfections and suggesting improvements thereon, with the further object of accomplishing a co-ordinated arrangement of improved apparatus which will satisfactorily and effectively recover and recharge into each individual furnace practically all flue dust produced by that furnace, at the furnace site, and accomplish this direct recovery of flue dust automatically, continuously and without labor or transportation cost, and with a minimum water and power requirement.

Though practice at various blast furnace plants differs as to the number and size of the dry dust catchers used, there is but slight difference in their design. They are usually of cylindrical shape with inverted conical bottom which forms a hopper for the dust and larger stock deposited therein. The top is usually dome or conical shape and the downcomer or downcomers, which conduct the gas from the top of the blast furnace, enter through the top or the side of the dust catcher. The gas outlet connection may occur at either place, but preferably opposite, or as far from the inlet or downcomer connection as possible. There is but little advantage gained by either arrangement, however, as the amount of dust precipitated in the dust catcher varies in accordance with the velocity and dust content of the gas passing through it, and the larger the dust the lower the velocity of the gas moving through it and the greater the dust precipitation therein.

Not much has been done toward accomplishing anything within the dust catcher other than possibilities in the economic handling of flue dust if designed s a separator for separating flue dust from the larger coke, ore and limestone stock discharged from the furnace during a slip. Separation of these grades would permit the fine dust to be sluiced or flushed out of the separator with the same water that is previously used to wash the gas in the wet gas washer thus accomplishing combination of all flue dust and necessitating but one method of handling thereafter. The larger stock brought down within the separator is freed from dust and held within the separator until drawn off into cars and taken to the ore, or coke bins to be recharged into the furnace.

The improvements in dust catcher design just proposed are met in the design shown in the drawing of the direct recovery process and described later.

The first and greatest saving in cost of handling flue dust and recovery of bulkier stock is possible of realization in this improved design, which may be termed the most vital of any of the improvements proposed, as it predetermines the extremely simple methods of handling the flue dust in wet form made possible by the separating and dust flushing features of the design.

At some plants further efforts are made to precipitate dust in the dry state, between the dry dust catcher and the wet gas washers, by installations of secondary dust catchers, dust legs or pockets and dry whirlers; all of which catch some dust as the gas passes through them. This would occur, however, if an almost infinite number of pieces of apparatus were used to recover the dust in a dry state, and it is for this reason that recent practice has inclined toward the omission of all dry dust catching devices between the first dry dust catcher and the wet gas washer, and installing the gas washer as close to the dust catcher as possible so that the connecting gas main may be shortened to the minimum and otherwise arranged to be self-cleaning, in that no dust will find a lodging place throughout its length.

Wet gas washer design has in the past covered widely different views on various types of apparatus for accomplishing the washing of dust from blast furnace gas, using water as the washing medium. All these types of washers may be roughly arranged into two groups, namely, power driven and stationary washers. Of the power driven washers the Theissein is a good example, and is one of the few designs of power driven washers remaining in practical use; and this for secondary, or final washing only, it being entirely out of consideration as a primary washer, or scrubber.

In the stationary group of washers the rain, or spray type, and the baffle types form two sub-divisions. By rain or spray type is meant those washers, or scrubbers, as they are more often called, wherein a rain, or spray, of water is dropped from a considerable height within a tower through which the gas travels upward, the dust carried by the gas being washed out by contact with the spray of water.

Within the baffle type washers, sprays of water are directed on baffiles made of wood or metal, the surfaces of which serve to retard the fall of the water as it falls from top to bottom of the scrubber. The baffles are so arranged that they split up the gas body as it travels upward through the scrubber and causes the gas to come into more intimate and positive contact with the wet surfaces of the baffles on which much of the dust impinges and is then washed off by the continuous spray of water directed on them.

Of the two types of stationary washers just described the baffle type has proven to be of greater efficiency for two reasons: First, because in the rain, or spray, type scrubber there are usually heavier sprays of water required to break up the gas body and penetrate it. Gas in moving through a spray acts much like wind with rain in a storm, a strong wind often being seen to blow sheets of rain at a sharp angle to the perpendicular, and gas acts likewise in a spray type scrubber, except—that being confined within the scrubber—the gas tends to travel through the spray. Second, in a well arranged baffle scrubber channelling is practically eliminated as the gas is split up into thin bodies which are compelled to travel between two wet walls which prevent their surging, or channelling. A further advantage is gained by the baffles in that they retard the fall of water, thus bringing a given quantity of water into longer contact with the gas and causing it thereby to wash out more dust from the gas.

The nature and position of baffles within a gas scrubber are determined by simple considerations; for example: If a wet board or sheet of metal one foot square is projected into a moving body of dirty gas, with its greatest area at right angles to the direction the gas is moving, it will be found to pick up no more dust from the dirty gas than if turned 90 degrees to the original position, while the resistance to the moving body of gas—with the baffles in the first position—would be much greater. It is for this reason that baffles are set edgewise or parallel to the direction of gas flow.

After exposure of one square foot of wet baffle surface to a body of dirty gas in the manner just described, it will be found to have collected a certain amount of dust in a given length of time. If twice the area of baffle surface is exposed to the dirty gas about double the amount of dust will be collected, and by provision of ample baffle surface a given volume of gas—of given dust content—is continuously cleaned or washed of dust by the action of the water spray directed on the baffles.

In the selection of materials for baffles, wood is usually chosen, mainly because it is cheaper material and because it can be readily built into the scrubber. Wooden baffles, however, have some serious disadvantages. One of these is the bulk of the wooden baffle, which is usually about an inch thick, and as the spaces between the baffles cannot be much less than an inch, because of the tendency to warp and thus close the openings between them, it is readily seen that baffles of wood occupy one-half of the cross sectional area of the scrubber in which they are placed, and on this account a scrubber shell of twice the diameter is necessary than would be required if thin plates or sheets not over 1-32-inch thick were used. This is a very serious consideration when arranging spray water distribution, as the area over which a given quantity of water is to be sprayed, is about twice as great with wooden baffles as would be required with thin sheet baffles.

A further objection to wooden baffles is their liability to being over-dried and warped if the water should go off the scrubber while in operation, while at least one instance is known where the baffles have taken fire during construction, causing the scrubber shell to buckle badly.

After having been washed by contact with wet baffles and spray, the gas has been cooled and cleaned of practically all dust, but on leaving the scrubber it carried with it considerable entrained moisture in the form of fine water mist, which has been picked up and carried along by the gas as it moves out of the scrubber at high velocity. It is, therefore, very desirable to remove this moisture, if possible, within the scrubber, and it is possible to remove much of this moisture by causing the gas to impinge on baffle surfaces not sprayed constantly with water. The moisture in the gas coming in contact with the baffle surfaces gathers on them, and, forming in drops, trickles down and off the baffles. For removal of moisture from gas in this manner the wooden baffle is not well suited because of its bulk, and as the drying area is necessarily considerable it would be impractical to consider this construction within a scrubber.

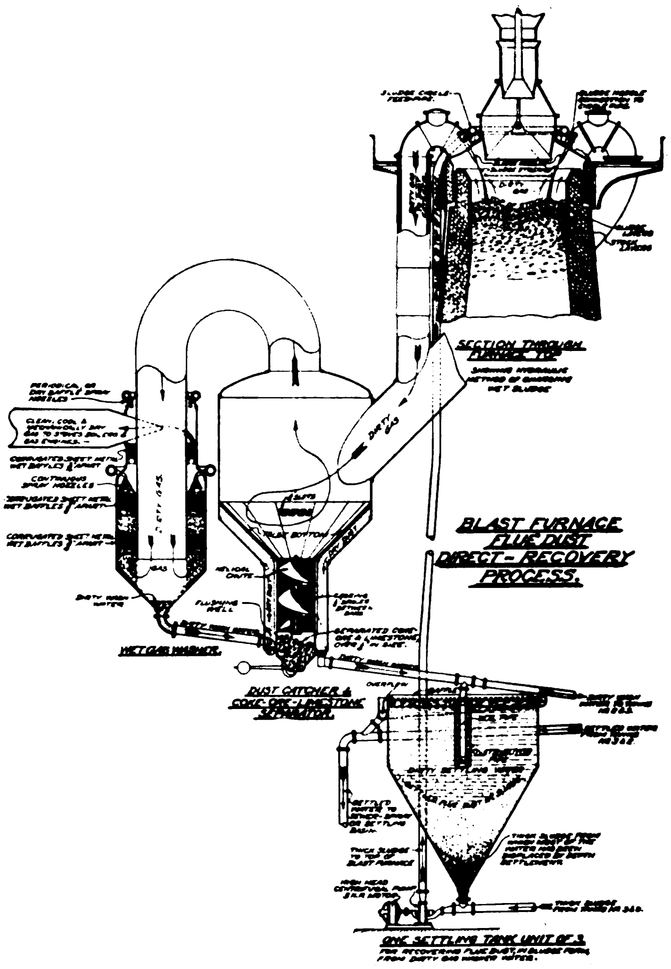
SECTION THROUGH FURNACE TOP
DIRTY GAS
CONTINUOUS SPRAY NOZZLES
BLAST FURNACE FLUE DUST DIRECT-RECOVERY PROCESS.
HELICAL CHUTE
FLUSHING WELL
GAS
WET GAS WASHER.
DUST CATCHER & COKE-ORE-LIMESTONE SEPARATOR.
OVERFLOW
ONE SETTLING TANK UNIT OF 3.

Fig. 1—Direct recovery plant.

Further consideration of these points of design are taken up later in the description of the gas washer, as represented in the accompanying drawing.

Probably as great, if not a greater problem, than that of gas washing itself is met with in considering proper methods for the disposal of dirty water from the gas washer. Government restrictions have in the past and will in the future, make it more imperative that water after using in blast furnace gas washers be first settled in properly constructed tanks, basins, or ponds of sufficient size to accomplish the retention of most of the dirt from the water before it is turned into public water courses where it rapidly clogs or obstructs the channels, the yearly deposits from a one-furnace plant alone being enormous.

From an economic viewpoint it is even more important that the gas washer water should be made to yield up its valuable burden of latent raw material. Several different designs of settling basins are in use, in most cases it being the practice to divert the water from all scrubbers to one basin, and for this reason the basin must be of such large dimensions as to necessitate its being located some distance from the furnaces, or scrubbers, in order to secure the space required for its installation.

The basin may be of single compartment construction or more usually of two or more compartments which permit of one being cleaned of the deposited flue dust sludge while the dirty wash water flows through the other. Cleaning, or dredging, is done with a locomotive, or overhead electric crane. A more recently developed design of settling basin accomplishes settlement and cleaning continuously in one circular basin, the cleaning being accomplished by use of a bottom scraper or plow mechanism, which works the sludge toward the center of the basin, from which point the sludge is then pumped.

At plants where it is the practice to recharge the wet sludge into the furnace, it would be a decided advantage to settle the dirty wash water in two or three tanks, the diameter of which need not be over 22 feet with a depth of 10 feet, to handle the dirty water from the gas washers of a modern furnace plant. Settling tanks of this size could, in most furnace plants, be located near the furnace. The tanks could be of deep conical bottom construction in which sludge could settle to considerable depth, and the greater the depth attained the more dense and less watery the sludge becomes. With this arrangement sludge at almost any desired consistency could be tapped off at the bottom of the tank and charged as desired.

Where it is regular practice to charge into the furnace all flue dust recovered in the wet form, and where it would be desirable to charge all dust produced, in the wet state, the problem is further complicated because of the dust, recovered in the dry state, which amounts to more than that recovered in the wet state. Dry dust at some plants, and both wet and dry dust at others, is transported to a sintering or briquetting plant, and after treatment, according to the process employed, the product in sinter or briquette form is returned to the furnace and charged in the usual way.

Consideration of either the sintering or briquetting processes for treatment of flue dust is obviated, however, if the flue dust is all combined and brought down in the wet form, as suggested in the foregoing, which leaves only the method of charging the flue dust into the furnace, open for consideration.

Where flue dust is treated either by the sintering or briquetting process, the method of charging is simple. The product from either plant is dumped into the stock bins at the furnace, where it is then charged into the stock larry car and thence into the skip car, as is all the coke, ore and limestone charged into the furnace.

Where all flue dust is to be brought down in the wet form, however, the method of charging is a matter of serious consideration. It has already been stated that at some plants wet flue dust is charged directly into the blast furnace without being either sintered or briquetted. This practice is not accomplished without considerable cost of hauling and other inconviences, and thus far no standardized system of handling or charging seems to have been developed.

At some plants both dry dust and all ore charged into the furnace are wet down with water just after being dumped into the skip car and before it is hoisted to the top of the furnace, where it is charged therein. An objection is always raised to this practice, however, because of the fouling effects of wet stock in the skip car and on the charging machine, but where the recovery of all flue dust in wet form is accomplished, as previously suggested, the charging of wet sludge is greatly simplified by application of the hydraulic system for lifting the wet sludge through a pipe to the top of the furnace where it can be easily distributed within the furnace through a circle pipe and specially designed nozzle which pierce the top cone of the furnace and introduce the sludge without bringing it into contact with any of the charging mechanism, accomplishing at the same time perfect distribution of the sludge, while the excess moisture in the sludge accomplishes a desirable wetting down of the other stock charged into the furnace in the usual manner.

The foregoing description of methods, practice and apparatus with suggestion for improvement therein, is based on actual operation, recent development, or experiment. The actual design of apparatus required to accomplish the suggested improvements, however, is represented in the accompanying drawing and described in the sequence of the order of their operation in the following:

The dust catcher shown is about of the usual design except that it has imposed about 18 inches above and inside its conical bottom a false conical bottom of plates having ¼-inch slots so arranged as to allow all fine dust and particles smaller than ¼-inch to pass from the upper to the lower chamber, which chambers are formed by the false bottom. The dust after passing through the false bottom drops into the true bottom of the dust catcher and slides thence into the dust flushing well where it is flushed out by the dirty wash water from the gas washer, which water has previously been used to wash out the remaining dust in the gas out of the gas washer.

Any particles brought down in the dust catcher that are too large to pass through the aforesaid ¼-inch slots in the false bottom simply slide down the false bottom into the helical chute in the bottom center of the dust catcher-separator. This helical chute is encaged in a cylindrical cage of bars with ¼-inch spaces between them. In ordinary operation this chute would not be required, but in cases of bad furnace slips, when tremendous quantities of coke, ore and limestone, with much fine dust, are suddenly thrown into the separator, much of the fine dust would remain unseparated except for the presence of the helical chute, down which all this stock must pass on being dropped out of the dust catcher-separator into cars in which it is carried to the stock bins. The chute inclines all material rolling down it against the encaging bars and the fines, or particles smaller than

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¼-inch sift out between the bars into the flushing well.

By this separation much valuable stock is immediately made available for recharging into the furnace, and without cost for screening, or otherwise handling, except transportation to the stock bins. The fine dust separated within the separator is carried out of the flushing well by the water from the gas washer, thus eliminating all cost of handling and treating in the dry state.

After dropping much of the heavier dust in the separator the gas passes through a self-cleaning gas main into the gash washer. It enters through the drop leg of this main, which drops vertically into the center of the washer. The purpose of this construction is to accomplish perfect gas distribution on entering the washer and drop a great part of the heavier dust—still carried by the gas—immediately into the bottom of the washer. A further object is to permit of the washer being used as a water seal gas valve. By this arrangement the transverse sectional area of the washer is lost to gas cleaning to the extent of the transverse sectional area of the gas main dropping through it, but the thin corrugated sheet metal baffles suggested occupy so little of the transverse sectional area of the washer, effective for gas washing, that the shell diameter of the washer may be even less than scrubbers in which wooden baffles are used. Furthermore, the area over which water spray must be distributed is so much less than that of larger diameters that a material increase in gas washing efficiency is obtained.

On entering the washer through the open end of the drop leg of the gas main the gas turns an angle of 180 degrees and rises uniformily up through the torrent of falling water and begins to pass through the lower set of baffles, which are of thin corrugated sheet metal and spaced about ¾-inch apart, being held thus by simple indentations of the corrugations, which occur at odd points on the sheets.

In the first, or lower, baffles each cubic foot of gas is subjected to 80 square feet of cleaning surface, using a standard 2 feet 3 inches width of corrugated sheets, and the gas is thereby cooled and cleaned of the heavier dust. The dust, combining with the water flowing down the surfaces of the baffles, is continuously washed into the bottom and thence out of the gas washer.

Still rising upward, the gas passes through a second set of baffles similar in construction to those just described, but spaced ⅜-inch apart. Each cubic foot of gas in passing through these baffles is subjected to 160 square feet of additional cleaning surface and is here thoroughly cleaned of dust and cooled to within a few degrees of the entering wash water.

The gas travels through these baffles at about half the velocity it traveled through the entering main, but above the continuous spray nozzles shown on the washer the shell is contracted to a smaller diameter, which construction accomplishes the increase of the gas velocity to that of the entering main. As has already been described, this increased velocity of the gas accomplishes more forceful impingement of the water mist it has picked up in the lower part of the washer, against the dry, or unsprayed baffles set in this section of the washer. These baffles are spaced about 3-16-inch apart and each cubic foot of gas in passing through them is subjected to 320 square feet of drying surface. As the mist continues to impinge on the baffle surface it forms into drops and flows down their surface and into the lower part of the washer.

Cleaning, cooling and drying the gas of entrained moisture is in this manner accomplished in one piece of apparatus, thus providing gas, which may be carried through comparatively small unlined mains, to the stoves, boilers or gas engines. The compact baffle arrangement described permits of low wash water pressure by reason of the greatly reduced height of the washer accomplished by this design, further permitting the bottom of the washer to be raised to a level sufficiently high to permit of the dirty wash water flowing from the washer to enter the dust catcher-separator, where it picks up additional dust, and from thence to flow into the settling tanks.

Dirty wash water carrying all dust brought down in the gas washer and dust catcher is run by gravity—as just described—through straight pipes to the settling tanks, which for a modern furnace plan would be three in number and about 22 feet in diameter, or 20 feet square with a depth of about 10 feet on the sides, which would permit of their being located in line with and beyond the dust catcher in most furnace plants. The water enters the tanks through a seal pipe, which prevents gas at all times from escaping from the dust catcher with the water. The water passes out into the tank through a perforated distributing pipe and thence travels at an ever-decreasing rate to the side wall of the tank, where it overflows. In passing slowly through the tank about 90 per cent of the flue dust in the water is precipitated therein and settles into the steep conical bottom of the tank in the form of a silt-like deposit, or sludge. The water flowing over the weir wall of the tank drops into a trough running around the tank and thence flows through a pipe to the sewer, which may carry it to a nearby stream, settling basin, or spray pond if the same water is to be used over again.

As the sludge settles to the bottom of tank to increasing depths, water is, to a great extent, displaced by the pressure of the upper mass of material so that at the bottom of the tank, where it is removed through the sludge pipe, the sludge would, under proper working conditions, contain not much in excess of 25 per cent water, which would permit of its being immediately charged into the furnace.

The nature and consistency of the recovered sludge make it possible to charge hydraulically with a high head centrifugal sludge pump with a power requirement of not more than five electrical horse power running continuously.

The sludge is collected and pumped through comparatively large pipes to reduce abrasion. The sludge enters the top of the furnace through a circle pipe and specially designed nozzles connecting thereto and piercing the top cone of the furnace. The nozzle openings are flat and are of sufficient number to distribute uniformily a ring of sludge onto the stock just under the large bell. This sludge ring distributes itself over the stock and the new charges of stock are dropped in on the sludge layers. Excess moisture in the sludge is therefore rapidly absorbed by upper and lower stock layers, thus accomplishing a wetting down of all stock, thereby lessening dust production.

The advantages gained by this system of flue dust recovery are:

First—Separation of fine flue dust from the bulkier stock is immediately accomplished, and the large stock made available for charging into the furnace.

Second—The fine flue dust is flushed out of the dust catcher-separator continuously by the same wash water that has previously been used for gas washing.

Third—The gas is thoroughly cleaned, cooled and mechanically dried, and may be conducted through relatively small unlined mains to small checker stoves, boilers, or gas engines.

Fourth—The water used in the gas washer carries all dust from both washer and separator to the settling tanks where all but about 10 per cent of the dust is recovered from the water in wet form, thus eliminating all cost of handling and treating contingent on recovery of dust in dry form, or when recovered part wet and part dry.

Fifth—All dust recovered in wet form is immediately available for charging into the furnace, eliminating the necessity of treatment by either the briquetting, or sintering, process.

Sixth—Flue dust in wet, or sludge form may be pumped into the top of the furnace accomplishing the wetting down of all stock and consequent retention of much of the dust that would otherwise be blown out of the furnace.

Seventh—Recovery of flue dust is accomplished at each furnace making possible the recharging of the same flue dust produced by that furnace.

Eighth—The dirty gas washer water is sufficiently purified to permit of its being run into a public watercourse.

Ninth—Water, power, transportation, labor and operating costs for this recovery process are less than that of any other.

Tenth—The first cost of constructing a direct recovery plant is negligible compared to that of plants for treatment of flue dust by any other process.

Development of the Steel Industry During the War in Germany

A General Review Showing the Various Improvements That Have Been Made in the Different Stages of Steel Manufacture in Germany During the Past Four Years.

By **HUBERT HERMANNS,**
Special Correspondent, Blast Furnace and Steel Plant.

PART III.

A COMPLETE review of the development of the electric drive for rolling mills in Germany will be published in one of the forthcoming issues of this magazine. We will, therefore, at present, only review briefly the advantages adherent to the electric drive.

These advantages are:

1. The remarkably good regulation. This regulation permits the rolls to bite easily and then to increase the rolling speed quickly to a maximum and to furnish rolling with a zero velocity. On account of the uniform torque the rolling speed can be considerably increased, increasing at the same time the output.
2. The posibility to transmit the energy without losses by means of conductors, which can be laid easily, safely and cheaply.
3. Elimination of losses due to shut downs, combined with the possibility of starting operation on shortest notice.
4. Small space requirements for the motors.
5. Easy measurements of the power requirements, which, in many cases, allow to draw conclusions in regard to errors or to possible improvements.

All these advantages have made, up to the present time, the electric drive superior to the steam drive. But, nevertheless, it can hardly be expected, that, in the near future, the electromotor will replace entirely the steam engine. This is due to the fact that economical and technical conditions in the different rolling mills vary within wide limits, mainly in regard to the power consumption. But an increased introduction of the electric drive has a direct advantage in so far as the increase in electric power demand permits a better and a more efficient working of the power station and thus permits a cut in the power costs. It is true this means a saving for all electrically driven installations, but it is, originally, due only to the increased electrification.

The general trend of improvement was, as in other countries, directed towards an increase in tonnage and a most extended utilization of the plant; a decrease in labor in order to make the operating expenses as low as possible, and, lastly, a reduction in accidents. Heavy mills are easier to operate with these improvements in view than wire mills. The unit weights of the billets are comparatively small in regard to the large cooling surfaces, for this reason it is not possible, to use the transportation facilities of heavy duty mills directly, that means without charges, for wire mills. In the first place the traveling speed must be increased considerably, and then, they must operate as automatically as possible. This automatic operation should be extended to the heating furnaces from the time the billets enter the furnaces until they enter the rolls. These movements have been made automatic by changing the furnaces to suit conditions. At the end of the furnaces the billets, now heated to rolling temperature, fall upon the rollers, which carry them to the rolls.

On the guide mills proper the main point under consideration was the replacing of the hand operation by automatic appliances. Charging the passes by hand does not only require many laborers, but it is dangerous and even when employing skilled men the rolling speed cannot be increased beyond a certain limit. These difficulties have been eliminated by the introduction of the automatic guides patented by Schoepf. These guides connect not only two adjacent passes on one stand, but also the adjacent stands. When changing from the oval pass into the square pass, the round sections are turned 90 degrees, whereas square sections are turned 45 degrees. Other designs of automatic guides have, so far, not been employed extensively. As far as the other auxiliaries for wire mills are concerned, much time and money has been spent to improve construction and design of wire drum with automatic discharge, of conveyors for the removal if the finished products and of low runways to save space. Fig. 10 shows a wire drum of the latest design. The wire, coming from the mill, is lead by a piece of pipe into the space between the outer and inner drum, which latter is revolving continuously in order to prevent buckling and breaking of the wire. After all the wire is wound up the motion of the drum is stopped and the buckets, which have supported the wire, are pulled back into the inside of the drum, thus permitting the wire bundle to fall down. This operation is automatic and controlled from the mill pulpit, whereas the starting and stopping of the drum is done by a separate operator.

The most important influence upon the charges in the design of the wire mills came from the introduction of the continuous and the semi-continuous mills and from the application of the electric power. In Germany the arrangement, as shown in Fig. 11, was preferred, which is the so-called semi-continuous, or German design. Here the roughing mill is divided into two groups of four stands each. Between these two groups is the shear for cutting the billets, which is mostly built as a flying shear. Quick automatic service and operation is insured by rollers before the first group as well as between the two. The finishing mill is also subdivided into two parts, which run with different speed.

When the German type was developed it was done with the intention of increasing the tonnage of the finishing mill by increasing the rolling speed of the rougher, the old arrangement of the finishing mill being well adapted for handling the larger tonnage. The results obtained up to the present time have proven this assumption to be correct.

In America the purely continuous mill is more generally used. This has not met with good success in Germany. This is due, on the one hand, to considerations in regard to the available space, because continuous mills require long buildings, and, on the other hand, to the high first cost for such types of mills. But there is another reason, which is derived from the shape of the finished product. The wire coming from a continuous mill is not perfectly round. This last point is not of a high importance for plants which refine the wire themselves. This is the reason that the wire mill Eschweiler of the Gelsenkirchener Bergwerks-A-G., selected, as the only wire mill in Germany, the pure, continuous type, because they refine nearly all their output themselves. This mill consists of a primary mill with seven stands and of a continuous finishing mill with 10 stands. The capacity of the mill is 150 tons of wire in 10 hours.

In general, and assuming normal conditions, it must be said, that, for the German rolling mill industry, there is no necessity for the installation of continuous wire mills. The small labor expenses are more than outbalanced by higher first cost, higher power consumption and larger wear and tear. In regard to the output, there is no difficulty in obtaining the same tonnage on a semi-continuous as on a continuous mill.

As for any other type of mills, electric drive has proven to be highly economical and efficient for wire mills. This type is rather well adapted for the use of electric power, because it requires a high speed and it runs with a fairly uniform load. For this reason standard type motors can be used, built ruggedly, of course, to suit the heavy operating conditions.

The current for driving the wire mill motors can be dc current, but general conditions in the mills are more favorable to the use of ac current. For this reason dc motors are not extensively used for mill drives, although their speed can be easier regulated than that of ac motors. For pure wire mills with a limited rolling schedule ac motors with speed regulators may be dispensed with, but they are important for such wire mills which are also used as merchant mills.

The details of the motors for the second group of roughing stands (in the front) and of the finishing stand (in the back) of a modern wire mill are as follows: The available power is ac current of 3,100 volumes and 42.5 cycles per second. The mill consists of a primary set with three groups of continuous stands and a finishing mill. The first group of the rougher, with 16.4-inch roll diameter, is driven by a direct connected motor of 1,500 to 3,000 effective hp and 213 rpm, the second group of four continuous stand of 10.4-inch diameter is driven by a motor with 1,200 to 2,400 effective hp, while the finishing mill with six stands, having a roll diameter of from 9.8-inch to 10.8-inch, is driven by a motor of 2,400 to 2,800 effective hp and 638 rpm. The third group of the continuous rougher is driven by a motor of 2,200 to 4,400 effective hp and 213 rpm, which also furnishes the power for two three-high mills connected to the last stand.

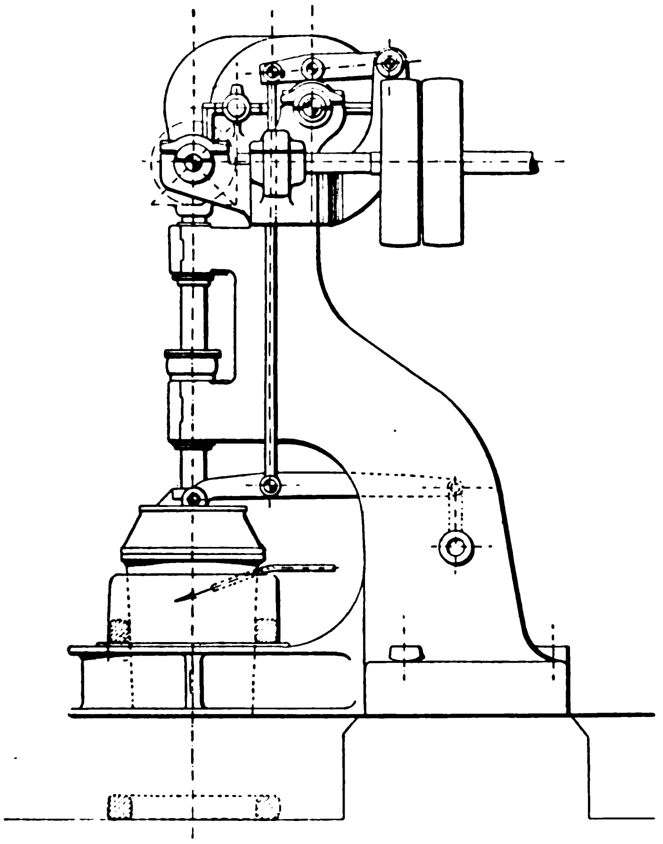


Fig. 10—Wire drum.

A few of the many and remarkable improvements of the electric drives for rolling mill auxiliaries may yet be mentioned. As a safeguard against a possible overloading of the motors, the fuses have been replaced by automatic circuit breakers, which prevent the loss of time due to a change of the fuses. These circuit breakers operate even when the engineer keeps the lever in closed position and intends to work with overload. The circuit remains broken, although the line connection may temporarily be cut out and thrown in again. When using controllers and copper switches, the automatic circuit breaker and the main circuit breaker are combined in an iron box, which, besides protecting the apparatus against dust, moisture, mechanical injuries, etc., has the advantage of preventing an unintentional touching of the charged parts.

The connection between the main circuit breaker on the pulpit with the power plant and the connection between the regulating apparatus and the motors is done by means of lead cables armed with flat iron. For the wiring on the pulpit connecting the different switches, controllers and resistances, high grade rubber covered and armored cables are employed.

The roll lathes require in the same manner as any other machine tools—drill press or ordinary lathe, a variation of the operating speed within wide limits and with very high exactness. It is very uneconomical, however, to obtain this result by means of bell cones or gear trains, but it can be easily obtained with a dc regulating motor, which is direct connected with the machine in question. It is built for rolls up to 40 inches diameter and for a maximum weight of 20 tons. The height of the checks is about 26½ inches and the distance between them about 20 feet. The speed can be varied by the motor between .5 and 30 rpm.

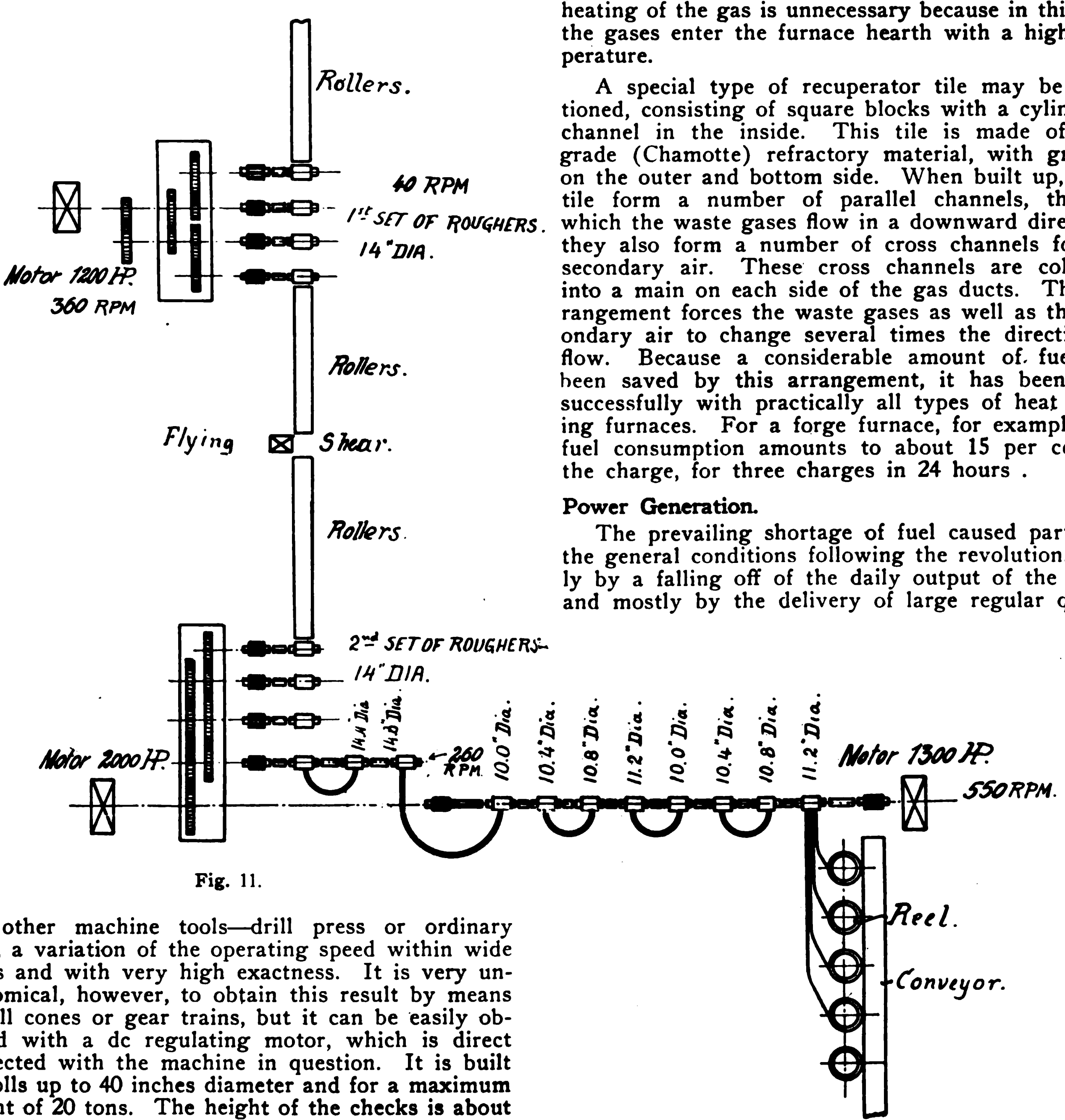


Fig. 11.

The other auxiliaries, such as saws, operating cylinders for adjusting the rolls, etc., are best and cheapest driven by dc current, even then, when for the rest of the mill ac current is supplied. This ac current can easily be transformed into dc current and used as such.

Heat Treating of Steel.

Apparatus for the heat treating of steel was designed with the view of increasing the output and of saving the fuel. The buck stays on the furnaces are arranged in such a way that the brickwork is easily accessible. The heat is utilized as much as possible by channels distributed around the brickwork and the waste gases are made to preheat the incoming air in a special type of recuperators. Wherever the producer forms an integral part of the furnace, preheating of the gas is unnecessary because in this case the gases enter the furnace hearth with a high temperature.

A special type of recuperator tile may be mentioned, consisting of square blocks with a cylindrical channel in the inside. This tile is made of high grade (Chamotte) refractory material, with grooves on the outer and bottom side. When built up, these tile form a number of parallel channels, through which the waste gases flow in a downward direction; they also form a number of cross channels for the secondary air. These cross channels are collected into a main on each side of the gas ducts. This arrangement forces the waste gases as well as the secondary air to change several times the direction of flow. Because a considerable amount of fuel has been saved by this arrangement, it has been used successfully with practically all types of heat treating furnaces. For a forge furnace, for example, the fuel consumption amounts to about 15 per cent of the charge, for three charges in 24 hours .

Power Generation.

The prevailing shortage of fuel caused partly by the general conditions following the revolution, partly by a falling off of the daily output of the mines and mostly by the delivery of large regular quantities of coal—according to the agreement of Spaa, 2,000,000 tons of coal per month—forced the industries to install aparatus which guaranteed a better utilization of the fuel, and allowed to use more low grade fuels.

It is not possible to enter into more details in this article and show all the numerous improvements which have been made in this direction. This will, however, be laid down in a later article, because many of these improvements are of high interest to the Amercian furnace engineer. Only a few installations for the unloading of railroad cars may be mentioned here.

The unloading of fuel as well as of other material on the railroads is done in Germany in entirely different ways than in America. In America automatic unloaders are used extensively, whereas the German railroad cannot apply these machines, because, in the first place, the road beds are not heavy enough for large weights, and in the second place, excessive changes, involving large sums of money would have to be made. It is true, experts have pointed, for many years, to the necessity of improving the heavy freight traffic, and chiefly the heavy industries have made many proposals, which may lead to improvements. The practical results of this work, however, were proportionately small. The railroad administrations, which are, as is well known, in the hands of the government, have permitted the use of some automatic unloaders, wherever the distance between the ore or coal mine and the blast furnace is short. But this permission favored only a few plants; the rest of the industries have to look out for themselves, when they desire to reduce their transportation costs.

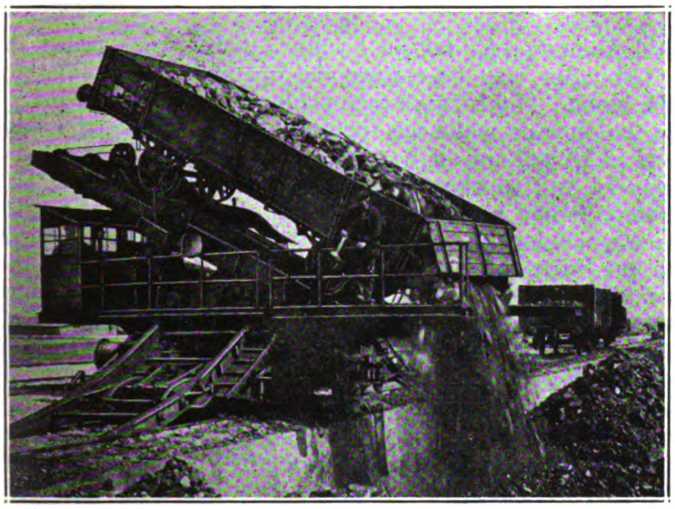


Fig. 12.

Necessity forced the development of automatic car dumpers to such a degree that, at present, they are highly efficient in all directions. This development was possible, because, in Germany, the open freight cars have doors on the two ends, through which the material is unloaded. The dumpers are mostly built stationary and can, for this reason, be uesd only at a certain place. If, on the other hand, material is to be unloaded at different places, stationary car dumpers can not be applied on account of their high first cost. This difficulty has been overcome by the design, shown in Fig. 12, which illustrates a traveling car dumper.

When designing this device, it had to be kept in mind, that the dumper is to be taken from one place to another, and for this reason, it has to be built in such a way that it could be coupled to a regular train between other cars. The tracks on each end of the dumper are, therefore, arranged in such a way that they can be lifted up and the movable platform can be locked. In this condition the dumper can be handled like an ordinary car.

The manner of operating these car dumpers is as follows:

The car which is to be unloaded is brought to and on top of the dumper by means of a revolving rope drum; it is then turned 90 degrees and dumped to the one side. The efficiency of this dumper is very high. Twelve cars of 15 tons each can be unloaded per hour.

For small tonnages another device has proven to be efficient during the last few years. This device consists of an elevator, which is suspended from a central shaft around which it can revolve. A shaft on the lower end contains a spital on each side, which force the material into a bucket conveyor. Similar contrivances have rendered good service during the war, when many plants had to store in the summer time large quantities of coal for winter use in a relatively small space.

ELECTRICAL ENGINEERS DISCUSS ECONOMIES.

Examples of large combustion losses in modern steel making featured addresses and discussion at the monthly meeting of the Chicago section of the Association of Iron and Steel Electrical Engineers, held at Hotel Morrison, Chicago, on February 19. The meeting followed a campaign for new members which practically doubled the enrollment of the section, 60 new names having been added to the list. The occasion was special in the sense that E. S. Jeffries, electrical engineer Steel Company of Canada, national president of the association; J. F. Kelly, national secretary, and A. H. Schwartz, Iron & Steel Equipment Co., Pittsburgh, chairman of the national program committee, were present.

Papers were read by John Sullivan, assistant superintendent Bessemer plant, Wisconsin Steel Works, on the Bessemer process of steel making, and by F. Von Schlegell, president Industrial Electric Furnace Company, Chicago, on the field of the electric furnace, particularly in the castings industry. Among those who participated in the discussion were H .J. Freyn, Freyn, Brassert & Co., Mr. Jeffries and Gordon Fox, electric engineer of Freyn, Brassert & Co., and chairman of the Chicago section of the association. Mr. Jeffries, in speaking on the subject of economies, cited what had been accomplished with the McCune type of open hearth furnace. Ordinarily it takes 8,000,000 Btu. to make a ton of steel in an open hearth, whereas in the McCune furnace only 4,000,000 Btu. are required. The average life of an open hearth furnace is 300 heats, whereas a McCune type furnace will yield 700 heats, he said, before it has to be relined.

It was announced at the meeting that the next annual convention of the National Association will be held at Chicago in September on dates as yet unfixed.

Heating Furnaces and Annealing Furnaces

A Critical Comparison of the Different Types of Furnaces in Use for the Heating of Heavy Forging Ingots.

By **W. TRINKS.**

PART XXVII.

THE present installment deals with a critical comparison of furnaces which are used for heating forging ingots and blooms or for heating partly forged pieces.

A factor which greatly influences the method of heating is the allowable rate of heating. In part II the reasons for the rule "20 minutes per inch of diameter in soft steel" and "30 to 40 minutes per inch of diameter in alloy steel," were explained, and in part XXVI, the temperature differences existing in the interior of the steel which is being heated at different rates were given numerically. In order to apply that knowledge to the problem in hand, it will be advisable to remember that steel which is heated too quickly shows internal cracks and fissures in the forgings quite aside from those which are due to gas occlusions in the ingot, or to defects in pouring practice or in shape of ingot. The larger the ingot, the greater is the temperature difference between surface and center for a given heating time. In consequence small bars and billets can be placed in a hot furnace without damage, while the same treatment injures large blooms or ingots. A further consequence is that in-and-out furnace containing three or four ingots cannot be charged again immediately after the removal of one of the hot ingots. The furnace must be emptied and cooled before it can be charged again with cold ingots, unless the latter are preheated. The immediate result is that any good size steam hammer or press must be fed by at least two furnaces so that one may be heating up while the other is being emptied. Often three furnaces are used. The type of furnace referred to here is illustrated by Fig. 202.

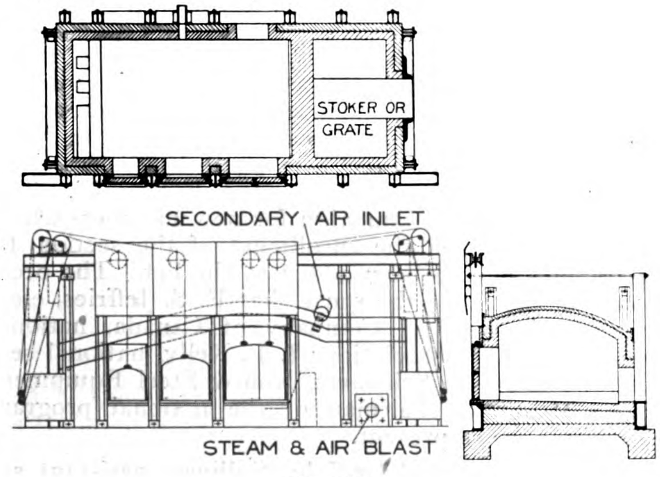


Fig. 202.

The furnace as well as the method of using it is simplicity itself, but the fuel consumption is outrageously high. More fuel is required to heat steel in this type of furnace than is required to melt steel in the open hearth furnace. The addition of a preheating furnace solves some of the difficulties, but lets others remain. If the preheating pit is separately fired, the only advantage by its use is that an ingot can be taken from the pit and can be put into the hot furnace in place of one which has just been taken out. That advantage is not cherished by the heaters, because of the radiation from the hot furnace, which is particularly annoying, while the opening on both sides of the tongue hold is being closed by brick and fireclay. As far as I know, there exists today no satisfactory way of closing the opening at the sides of the ingot. The furnace men prefer to build up the bricks in the opening while the furnace is cold, or else, if ingots are to be put into a hot furnace, to shove them all the way in and to close the door all the way down. The latter method necessitates the use of a manipulating device which lets go of the ingot after it has been laid down in the furnace and which, later on, grabs hold of the heated ingot without loss of time and without exposing the heater to the intense radiation of the furnace. And it also necessitates the use of sink heads of the same size on all ingots, or else interchangeable jaws on the manipulator head to fit different size sink heads. There is plenty of room left for inventive genius to devise ways and means for closing the openings below the door and at the sides of the ingot, when the furnace is at a temperature of 2200 degrees F.

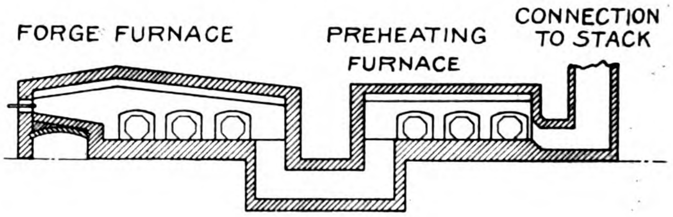


Fig. 203.

If a preheating furnace is attached to the main furnace, and is heated by the waste heat from the main furnace, see Fig. 203, the fuel consumption per ton of ingot heated drops considerably. The arrangement might appear ideal because of the lowered fuel consumption, and because the preheating positively prevents internal cracks and fissures in the forgings. But there are practical difficulties. First, there are all of those difficulties which were mentioned in the preceeding paragraph with the

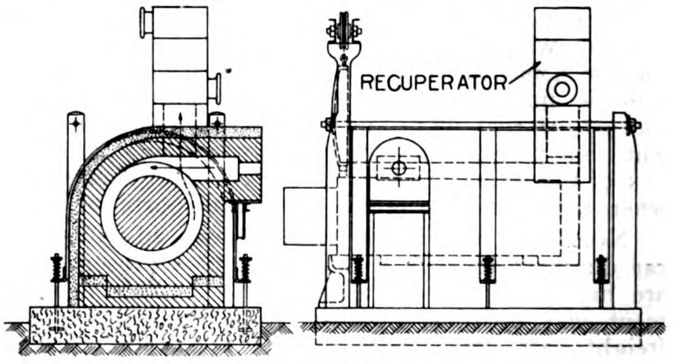


Fig. 204.

added difficulty that each ingot must be handled twice as often as before. The upshot is that the preheating furnace is used rather seldom.

If a preheating furnace is attached to a high temperature forge furnace, the connecting flues must be made quite large, (roughly speaking, with not more than 20 feet per second), to prevent excessive infiltration of cold air into the preheating section.

Since several furnaces must be used in any event, it appears logical to carry the subdivision still further and to use only one, or not more than two ingots per furnace. With individual furnaces the radiation losses will be greater, but the system affords a much greater flexibility on account of an almost continuous working. One or two furnaces are cooling down, others are heating; a medium warm furnace can have the openings around the ingots closed up; another furnace may be repaired, and so on. The principal drawback to the one ingot per furnace system lies in the large floor space requirements. The fuel consumption of this furnace may be kept within reasonable limits by the use of the "Rota-flame" principle, see Fig. 204. The flame is projected into the furnace at high velocity. The space between the furnace and the ingots must be reasonably small so that the flame will keep on whirling until it reaches the flue. The heat is greatest, where the ingot looses heat through the door opening, (see Part V), and yet the direction of the flame is such as to not throw any flame out at the door. During a large part of the heating period, the flue gases leave the furnace with a comparatively low temperature. The cylindrical shape of the furnace reduces the radiating surface as much as it can be reduced with individual furnaces. If further fuel reduction is desired, a cast iron recuperator can be put on top of the flue for preheating the combustion air. Furthermore, the furnace can be insulated with Sil-O-Cel or Nonpareil. In that case the bricks which are struck by the hottest flame must be of the very highest quality, such as suprafrax, carborundum or magnesite. A drawback of the roto-flame principle is that there should be different sizes of furnaces for the different size ingots.

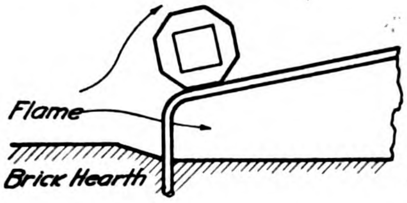


Fig. 205.

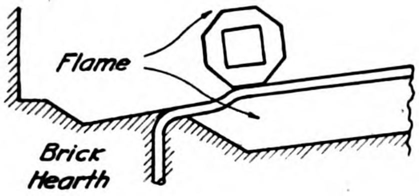


Fig. 206.

Since the regenerative principle has been a fuel saver in many heating and melting operations, it has also been applied to heating furnaces for heavy ingots. Its success is impaired by the fact that, before a new charge can be put into the furnace, the latter, including the checkers, must be cooled down. The greater the mass of brick in the furnace and the checkers, the greater is the loss due to cooling between heats. In a single-ingot forge furnace of good repute, it was found by test that the heat which was put into the brickwork and which was dissipated between ingots amounted to over 30 per cent of the total heat liberated by the fuel and to about double the heat stored up in the heated steel. Arrangements might be made by means of which the heat of the checkers can be retained, while the furnace proper is being cooled off, but any such arrangements would introduce additional complications. A better plan would be to use very thin, long, checker tile, not more than 1¼ inch thick, solid chimney construction, for the purpose of minimizing the useless heat storage.

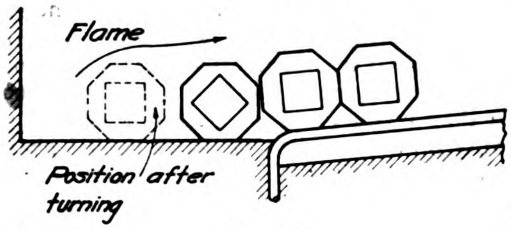


Fig. 207.

In this connection it should be noted that the forge furnace for heavy ingots is quite different from the "soaking pit" or more properly speaking, the pit furnace. The latter is charged with hot ingots fresh from the ingot stripper, and works at all times at high temperatures, while the forge furnace must be pulled down to 1400 degrees F. between heats.

Everything considered, it appears that the individual ingot furnace with the whirling flame and with recuperation of some of the waste heat is the best for the all-around heating of heavy ingots, particularly if it is made of thin walls of the highest grade firebrick, covered with insulating material.

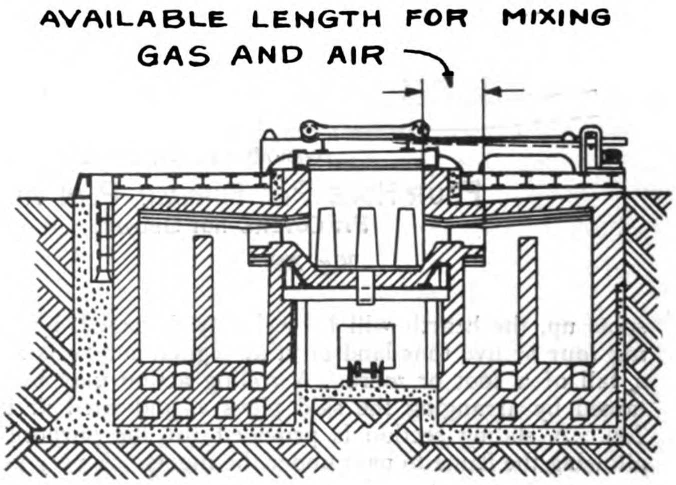


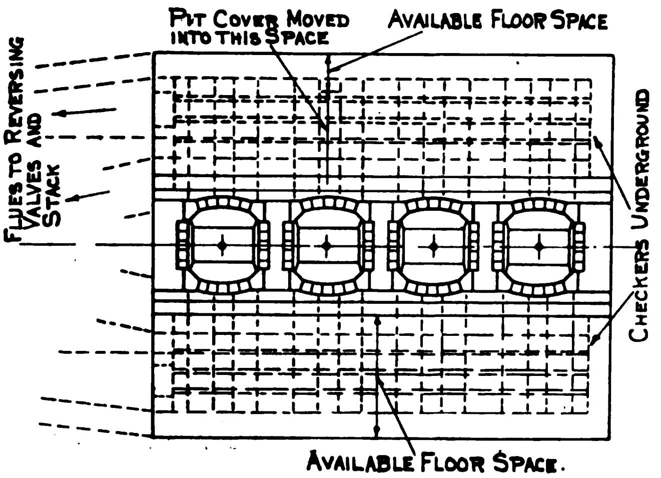
Fig. 208.

Extremely heavy ingots, such as used for naval guns, are heated on a car, because of difficulties in handling.

Conditions are quite different, as soon as ingots of uniform size are to be heated, such as occur in large orders of marine shafting railroad axles, wheel tires, etc. In a plant doing repetition work of this sort, a continuous furnace, or a group of continuous furnaces is a good investment, provided that the work is properly engineered.

Ingots up to 23 inches diameter (or rather short side of octagon) have been successfully pushed over pipe skids and have been heated to forging heats in continuous furnaces. The difficult part of these furnaces lies in the construction of the forehearth. On account of the large weight of the ingots, wide skid rails are used (2½ inch pipe or larger) and wide black spots are produced. From part XXIV it is quite clear that the vanishing of large black spots takes about a quarter of an hour. The ingots must, therefore, stay on the fore hearth for at least that length of time, after having been turned over. It goes without saying that ingots of that size and weight cannot be pushed across a brick hearth, because of the damage which they would do to a soft, slaggy hearth, and because they could never be heated with any degree of uniformity on a ventilated or water cooled hearth, while resting on the latter with the black spots of the ingots down.

The whole difficulty of forehearth design lies in the turning over of the ingot. If, as indicated in Fig. 205, the ingot is allowed to drop so that it will bring the cold spots up, the hearth will be seriously damaged, by having four or five tons land on it at regular intervals after a fall of a foot or more. A rolling action may be obtained by arranging the skid pipes as indicated in Fig. 206. A sliding section is provided for the purpose of allowing the flame to pass under the ingots. A very positive turning action can be obtained by letting the manipulator reach into furnace and turn the ingot, see Fig. 207. In that case the dropping and sliding are avoided, but there is no chance for the flame to pass freely to tne under side of the ingots. Besides, two furnaces must be used or else a very long forehearth must be provided. In the cast of two furnaces, the manipulator reaches into one furnace to turn an ingot over, and then reaches into the other furnace for the purpose of pulling out an ingot. In the case of one furnace, an ingot, (call it No. 1), must be moved out of the road; another ingot, (call it No. 2), must be turned, and then the first ingot, (No. 1), must be picked up and taken out by the manipulator. This procedure causes loss of time, undesirable heating up of the end of the manipular and great heat losses from the furnace on account of a very large door's being open for a considerable length of time.


Pit Cover Moved into this Space
Available Floor Space
Flues to Reversing Valves and Stack
Checkers Underground
Available Floor Space.

Four Hole Pit Furnace, Plan View
Pit Covers Not Shown.

Fig. 209.

"Vertical heating," as it is called, appears very attractive and is much used in soaking pits of steel works. On the other hand it is found very seldom in forge plants. The reasons for this difference are quite obvious. Odd shaped, partly finished forgings cannot be reheated in a vertical position, and various sizes of ingot cause difficulty in handling. Short ingots for small forgings, are almost lost in the pit and are hard to pick up, while long ingots stick up through the top and require the making of special pit covers. As a rule, pit furnaces are built without sufficient room for flame development between the burner and the ingot, see Fig. 208. With hot charged ingots, very little flame is needed, and the scaling is not excessive, but with a cold charge, there must, of necessity, be a greater fuel consumption in unit time, a longer flame, and more free oxygen at the place where the ingots stand. This fact means that pit furnaces for cold ingots should be designed with more room than the standard pit for steel works. However, that precaution is very seldom used.

Pit furnaces take up a comparatively small floor space, as may be judged from Fig. 209. On account of the underground construction it is generally believed that radiation losses are small. For long forging ingots that belief is rather imaginary, because it has been found necessary to ventilate the walls between the cells, in order to keep ingots leaning against a partition wall from pushing the wall into the next cell. The ventilating feature consists of structural steelwork between two brick walls. The walls are strengthened sufficiently by this design, but the supposed saving of radiation losses has largely disappeared.

It is thus seen that no one type of forge furnace for heavy ingots combines all of the advantages or gets rid of all of the disadvantages. No matter what we may do in excellence of design, there is always some feature with which fault may be found.

FIRST INGOT CAST AT NEW NAVAL ORDNANCE PLANT.

On February 2, 1921, the first armor plate ingot was cast at the United States Naval Ordnance Plant in South Charleston, W. Va.

This marked the formal opening of the Navy owned steel plant, which has been under consturction for the past two years.

The event was witnessed by Gordon Woodbury, Assistant Secretary of the Navy, Admiral C. B. McVay, Chief of the Bureau of Ordnance, Navy Department, Captain George R. Marvell, Inspector of Ordnance in Charge, and many invited guests. The work was supervised by William J. Priestley, Steel Superintendent.

In order to obtain steel for armor plate of greater resisting qualities, electric furnaces have been installed for refining and perfecting the steel as it comes from the open hearth furnaces.

WHEELING STEEL REBUILDING.

Freyn, Brassert & Co., Chicago, have been engaged as consulting engineers by the Wheeling Steel Corporation in the rebuilding and remodeling of No. 1 LaBelle furnace and of the Martins Ferry plant. At La Belle the improvements will consist of enlargement of the furnace for augmented capacity, together with relining of the hot blast stoves and installation of a gas cleaning system complete with other parts.

Discussion on "Electric Steel" Paper

Recent Paper Prepared by C. G. Carlisle on "Strength In Electric Steel," and Presented Before British Iron and Steel Institute Discussed.

By R. J. WEITLANER,
Electric Steel and Forge Company.

THE writer of this article would like to discuss a few points in connection with a paper presented by C. G. Carlisle before the British Iron and Steel Institute September, 1920, and reprinted in THE AMERICAN DROP FORGER, October, 1920.

All those familiar with the production of quality steel in the electric furnace will agree with the author that failures of electric steel were mostly due to lack of experience on the part of those directly responsible with the manufacture, this fact being especially the case during the rapid installation of electric furnaces during the war times and cannot be any inherent defects of the electric furnace process as developed so far.

It is however, very doubtful if any cases could be cited where steel was made in the United States by the clock method as so graphically described by the British metallurgist, the much talked of tonnage in this country notwithstanding.

The author discusses the removal of sulphur and phosphorus in the basic electric furnace by the well known equations but mentions a resulphurization of the bath, to the following equation:

$$CaSO4 + 4Fe = FeS + 3FeO + CaO$$

*I do not think that calcium sulphate is a stable compound at such high temperatures as prevail in the electric furnace, but am rather inclined to ascribe this throwing back of sulphur into the bath to the reversible equation.

$$CaS + FeO = FeS + CaO$$

This reaction is very likely to occur when a good deoxidizing slag is allowed to fall back due to lack of attention on the part of the melter the slag changing its appearance from a light to a dark color.

This falling back of a well deoxidizing slag is very often caused by the dropping of silica bricks into a deoxidizing slag, reducing its basicity and destroying its reducing capacity. This latter action may perhaps be explained by the equation:

$$2CaC_2 + 3SiO_2 + 3Fe = 2CaO + 3FeSi + CO$$

resulting in an increase of silicon in the bath but at the same time weakening its reducing action, and through absorbing of FeO and MnO turning into a slag unfit for a proper finish.

Such a case is liable to occur in the final stages of a melt, when it becomes necessary to bring the bath to its proper tapping temperature.

Quick addition of lime and coke and simultaneous lowering of the temperature will in most cases undo the damage, but in cases where a large amount of slag has been allowed to accumulate the best remedy is to draw off the greater part of it.

I must also take exception to the statement in this paper that the size of the electric furnace is mainly the cause of a higher sulphur and phosphorus content in the final product.

It is true that the surface of the bath increases with the square of the circumscribed sphere whereas the volume of the bath increases with the cube of the radius of the sphere, on the other hand a deep bottom in any size furnace will influence the proportion of surface to volume in a way detrimental to the action of the slag upon the metal.

But the fact that sulphur and phosphorus may be somewhat higher in melts from larger size furnaces is also due to the fact that a larger proportion of slag to metal is used in smaller furnaces as compared to larger furnaces, and furthermore that the time for reaction between slag and steel is not proportional to the increase in tonnage between large and small furnaces.

Desulphurization can certainly be carried out to a very low percentage of sulphur even in large furnaces if a greater amount of time and care is taken for this stage of the operation and when slag materials, like lime, spar and coke of greatest purity are used.

The concentration of sulphur in steel and slag has a great deal to do with the reactions taking place between the two media. If impure lime or spar (the latter often contaminated with an unusually high constant in sulphides of lead and zinc) is used, the elimination of sulphur cannot be carried down to extremely low sulphur percentage.

The elimination of phosphorus should not present any greater difficulties than that of sulphur, provided again enough time be allowed for its absorption by the slag.

Here however, rephosphorization is liable to occur through an excessive cutting of the banks during the reducing period and through phosphorus contained in additions like ferro-manganese, etc.

Another possible explanation for the lower percentage of sulphur and phosphorus in steel made in a smaller furnace has been given in a correspondence published in "Iron Age," December 23, 1920, page 1686, explaining the advantages of bottom connected furnaces, resulting in a circulation of the bath, and giving a better contact between slag and metal.

Aside from all these comments on the subject of electric furnace practice, we must heartily agree with the author's conclusion that the final slag plays a more important role as to soundness of the finished product in the basic electric furnace than in any other metallurgical process.

A few minutes inattention may change a perfect deoxidizing slag into a thin cutting slag full of oxides and when tapped resulting in unsound material which cannot be offset by the addition of a killing agent.

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*Compare Hofmann, "General Metallurgy," 1913, pages 96 and 99, where we find the heat of decomposition for $CaSO_4$ to begin at 1250 degrees C.

The Logic of Roll Design

Describing Why Flanges Must Be Reduced in the Part of the Groove—Rolling Rails Diagonally—Demonstrations Covering the Principles of Roll Designs.

By W. H. MELANEY.

PART III.

IN the two former articles the simpler forms of roll design have been explained, together with the reason why the general forms shown are usually followed. In this article the writer will endeavor to show that in other sections, such as channels, beams, etc., in which deep flanges occur, and which can not be slabbed under any of the methods heretofore shown, that an entirely different principle is brought into play, to accomplish the same general result, namely, the slabbing down of the metal into a thin flange, wherever such flanges occur in the production of any desired section and also show why the flow of steel does not always follow the path the roll designer wants it to. And right here is where some of the so-called mystery in roll design comes in, because as previously stated, the flow of the steel will follow the path of least resistance and when it does not seem to do so you will find that the reasoning with which this seems to be at varience is faulty.

Rolling Rails Diagonally.

The rolling of a rail diagonally (See Fig. 6) brings into play a part of two slabbing actions. That used on rails as ordinarily rolled and the other one used on beam flanges. This latter action will be explained in detail under beams.

While the angle at which a rail may be entered into a groove, when rolled diagonally, is limited by the amount of taper in the flanges, the more it can be placed on the diagonal the greater the slabbing action, as under this condition it more nearly approaches the simplest slabbing position.

In Fig. (6) the slabbing of the flange is done in the open part of groove, as described on some of the other sections and is taken care of without turning the rail upside down, as is done under the ordinary process.

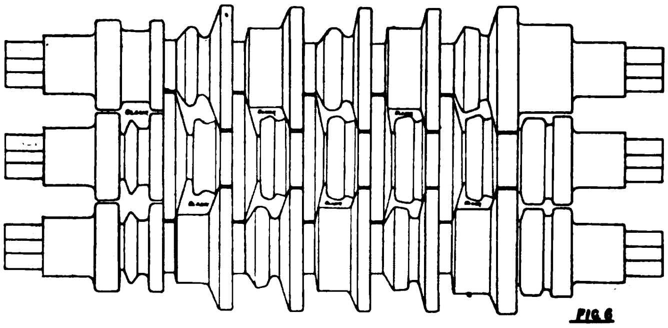

FIG. 6

The reduction of the flange takes place between the tongue of one roll and the collar of the other roll, on one side of the roll only, and the other flange is permitted to drop into the closed part of the groove with practically no side draft on the flange proper, but with sufficient reduction in the height of flanges to take care of elongation, and make the rail deliver straight. In this type of roll the flanges in the open part of groove are usually cut away at the end, permitting the flange to spread at will without danger of finning. Its height being controlled by the closed part of groove in the next pass.

As no slabbing action can take place in the closed part of groove, the flange on one side of rail is reduced in the open part of groove and the opposite flange is reduced at the next pass, also in the open part of next groove. This takes place all the way down to leader pass, where the rail is evened up for entrance into the finishing pass.

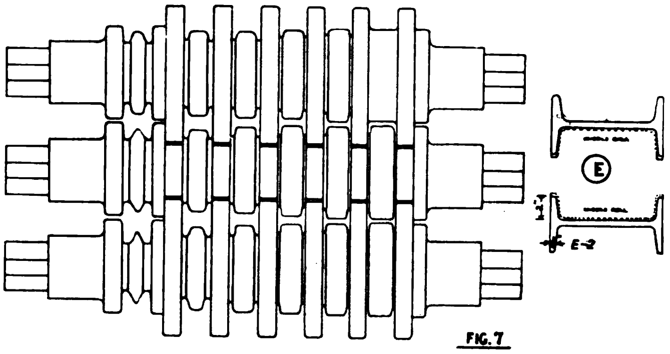

FIG. 7

You will note that the finishing pass is set parallel with the pitch line, and not on the diagonal, as in the other passes, as its use is to bring the rail to accurate dimensions all over.

In the present illustration (Fig. 6) the reduction from a bloom to a rail is shown in one set of rolls. It is obvious that two sets could be used if desired in order to shorten the rolls and facilitate production.

The most common use for this type of roll is where a large size rail is reduced to a finished rail of smaller section, as considerable upsetting action on height of rail can be obtained in each pass, and the rail gradually reduced in height to the size desired.

Channel Iron.

This section being similar to half a beam split lengthwise of section that is a web with flanges on each end, but extending on one side of the web only. This presents similar difficulties as are met with in rolling a beam, except that as the flanges are on one side of web only, they can be curved outward if desired, and a greater slabbing action obtained than is possible on a straight or perpendicular flange. Where deep flanges are required, this outward curve of the flange is used. Also on large sizes, as they can be rolled from a thinner slab and the same action obtained as in the butterfly angle.

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The smaller sizes are usually rolled similar to a beam and the same principle used to produce the flanges as are used on a beam. This will be explained in detail under I Beams.

Rolling I Beams.

The rolling of an I beam presents a different condition than any of the sections described previously, as it has flanges both sides of the web and on both ends of the section, therefore, it is rolled with the flanges vertical (Fig. 7).

The ordinary slabbing effect, such as previously described, can not be obtained on this section, so an entirely different principle is used. Assuming, as stated, that the flow of the steel in rolling will follow the path of least resistance, then if a beam pass was designed with an equal amount of reduction on the sides of the flanges, on both sides of the beam, the uninitiated might see no good reason why the steel should not fill both sides of the groove equally, as the reduction on both sides would, under this condition, seem to be exactly the same. But such would not be the case.

The flanges on the open part of the groove would overfill and force the steel between the tongue of one roll, and the collar of the other roll, thus producing a fin, and the flanges in the closed part of groove would fail to fill up, leaving the flanges short in length. This results because the resistance to the flow of the steel is greater on one side of the bar than it is on the other, and is due to two reasons:

First, because one side of the beam is being rolled in the open part of groove and the other side of beam in the closed part of groove, and second, because the open part offers less resistance to the flow of the steel, because of the following conditions:

Place between the palms of your hands a lump of moist clay or putty, as shown in Fig. 8-H, press the hands tightly together and you will find it takes considerable pressure to squash the clay into a flat mass. But, if while applying this pressure you also give your hands a semi-rotary motion, as shown in Fig. 8-J, you will find that the clay will spread over a much greater surface and with less pressure than was required without this motion.

This is because you have produced a slabbing action, but by a different method than has been described heretofore. This is the type of slabbing action that is produced between the tongue of one roll and the collar of the other roll, in the open side of groove and is entirely absent on the other, or closed side of groove, and as a consequence, the steel will flow into the open side of groove as the path of least resistance, and away from the closed part of groove.

If you will refer to Fig. 8-G, showing an end section of the rolls, you will note that the tongue of one roll and the collar of the other roll are both revolving toward the vertical center line of rolls, but due to the difference in their diameters, are traveling at different speeds, producing a certain amount of sliding action between the two surfaces. This causes a spreading of the steel and at the same time forces the steel towards the vertical center line, crowding it in until this line is reached. Then the two surfaces start to receed from each other, immediately releasing the steel from pressure between the two surfaces, and permitting it to deliver without resistance. This has produced the same quashing action that took place between your hands when given the semi-rotary action (Fig. 8-J).

This action takes place on one side of the groove only, as all the surfaces on the closed side of groove move in unison, no slabbing action can take place and all parts of the flange on the closed side of the groove offers the same resistance to the flow of the steel into the flange groove, and if no other cause intervened, the steel would still flow into the open part of pass, as its path of least resistance.

But another element also intrudes itself to accentuate this action. Say the flanges were 2 inches high but only ¼ inch thick and tapered full length of flange. (See Fig. 7-E-2). Now suppose you wished to reduce the flange 1-16 inch in thickness. It is apparent that to force this flange into a tapered close flange groove, such as exists on the closed part of groove, you would have to reduce the flange 1-16 inch in thickness over the entire surface of its 2-inch height. While to upset or reduce the height of flange would only require a reduction over a section equal to its ¼-inch thickness (Fig. 7-E). Therefore, as there is no slabbing action in this close groove and every part of the flange is subjected to practically the same pressure, the steel flows in the direction of least resistance, which is to reduce the height of the flange rather than its thickness, because this part of the flange has the least area and the flange would come out of this groove shorter than it went in, because of the upsetting action on the flange.

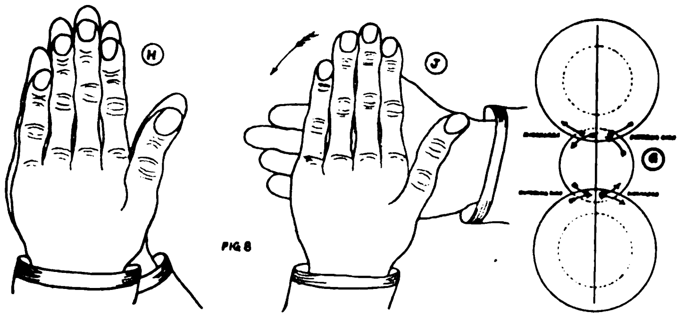

FIG 8

A flange will only drop into a close tapered groove to a depth sufficient to cause enough pressure to upset its cross section (Fig. E-2) and ride there. The extra metal being forced into the open side of groove and over filling it, so that the bar as delivered from this groove would have the flanges on open side overfilled, and the flanges on the closed side not filled up.

Therefore, the logical thing to do is to reduce the flanges in thickness on the open part of groove only. In other words, between the tongue of one roll and the collar of the other roll. This reduces the flanges on one side of beam at a time, the flanges of other side dropping into the close grooves (Fig. 7-E), then on next pass this same action takes place on the other flanges and without turning the beam over as on a three-high set of rolls, the tongue roll is on top of the bar when entered on the bottom pass and on bottom of the bar when entered on top pass.

This means that the flanges on one side of beam will be thicker than those on the other side after every other pass, except the finishing pass. The next to finishing pass being one where the flanges are equal.

(Continued on page 238)

On The Manufacture of Seamless Tubes

A Series of Articles Based on the Origin of Seamless Tube Rolling in Germany, With Special Consideration of the Mannesmann Oblique Rolling Process.

By DR. ING. KARL GRUBER IN RHEYDT.

PART I.

THE brothers Mannesmann of Remscheid have the distinction of having been the first to find out that it is possible to hollow roll round bar between rolls that are arranged in a warped plane. This invention caused a tremendous stir in the whole engineering world in 1888-90, more especially so as the inventors were expecting a far more extensive utilization of the process at the time than what was actually realized later on. Oblique rolling mills had been known for about 10 years, but they were used for straightening and polishing of round bars and tubes only.

The first patent for making tubes by means of oblique rolling mills was granted in Germany in 1886 under No. 24,617, through the instrumentality of the brothers Mannesmann, to Dr. F. Koegel and, based on the invention, rolling mills were erected in Remscheid, in Bons, near Saarbruecken, as well as in Bohemia, in Komotan, later on in Landore, in Wales, and also in Rath, near Duesseldorf. The process, however, experienced may difficulties right from the beginning and, although monetary assistance came from all sides, it was unable to attain the success hoped for. The cause of the failures was mainly due to the attempts to produce finished tubes on the oblique rolling mills, a method which, later on, has been completely abandoned.

The trouble was not so much with the designs, which were perfectly developed, but with the material which could not be made or produced of sufficient homogenousness as required for the oblique rolling process, viz.: in a state in which the molecules showed adequate cohesive properties. Material showing cracks and pipe even today causes a lot of trouble, with perfect equipment.

The oblique rolling mill is now only used as cogging, or blooming mill, for producing, from round bar, hollow shells of from 20 to 30 mm thickness of wall and such weight as to produce tubes of from 8 to 10 and even 12 m in length. For making finished tubes of from 2½ to 10 or 12 mm thickness of wall, finishing rolls are used, which are another invention of the brothers Mannesmann and go by the name of pilgrims-step rolling mills (Perrins process); they were patented in Germany for the first time under No. 58,762.

The oblique rolling mill, with face plates, has been developed further by the German-Swiss R. C. Steifel, who lives in the States, for the Engineering Company, Ellwood City, Pa., on similar lines to those laid down by the first Mannesmann patent specification (No. 34,617).

In the following the basic principle of the oblique rolling process is to be investigated somewhat more closely, following in doing this a paper read by Prof. Reuleaux before the Berlin district association on April 16, 1890.

Let us assume that there is a specimen A with a shaft supported by bearings and that a roll B, arranged obliquely in relation to the axis of the specimen, can be rotated while pressing against the latter The bearings of the specimen A permit rotary and lengthwise movement of the latter.

If now roll B is rotated, the rotary movement is transmitted to the specimen A, but at the same time a lateral movement of the specimen A takes place, the movements being as follows: For a peripheral speed of the roll v, the rotary movement of the specimen is v cos β and the speed of the lateral movement amounts to v sin β where β is the angle of intersection of the two shafts. The force by which rotation and thrust are caused is provided by the pressure between roll B and specimen A. Let us suppose further that on the other side of the specimen A another pressed-on roll is arranged the shaft of which also forms an angle β with the axis of the specimen, then it follows that a more reliable lateral and rotary movement of the specimen is secured.

If now the specimen A is arranged in the bearing C in such a way that it cannot be shifted in the direction of its axis, in the point of contact of roll B with the specimen A a tendency will develop which tries to force the molecules of the surface in the direction of the side thrust mentioned above. This action probably does not take any effect at first except in the shape of wear of the surface. Still it leads to the basic principle of the oblique rolling process.

Now describing the process in its essentials as it actually takes place. The specimen A is kept back by a taper on the rolls and its surface molecules are pushed forward by means of roll B, which grips the specimen A. This action is not confined to the surface but extends down into the hot interior of the specimen A, the effect being, as I shall explain more fully later on, that material is drawn from the interior and moves spiral shape to the surface, and in a forward direction. The former assumption, viz.: that a mandrel has to be provided holding back the core of the material if the proper formation of a hollow is to be assured, does not appear to hold good. This view seems to have been held by the inventors, and also by Prof. Reuleaux.

The hollow bloom is formed even without a mandrel being used and the mandrel of the rolling mill serves the purpose only to equalize the thickness of wall of the material and to smooth its interior, and it is essential only, in the main, for the finishing pass of the specimen A.

(Continued in April issue)

Reprinted from Stahl und Eisen.

The Basic Open Hearth Melting Shop Equipment and Practice

A General Review of the Mixer Plant and Practice—Melting Furnaces — Metallurgical Practice — Handling of Materials and Products—Layout of the Plant.

By GEORGE A. V. RUSSELL,
Assistant Plant Manager—Sheffield, England.

PART II.

THE author approaches this next section of his paper with much diffrdence as he is far from competent to deal with this aspect of melting shop practice in a manner worthy of the way it should be treated, and when its magnitude and interest are taken into consideration it will be readily understood that the necessary limitations of space in a paper such as this would preclude anything but a very perfunctory treatment of it if one attempted to range over the whole of this wide and most fascinating field. He thought therefore that instead of endeavoring to give a general resume it might be more profitable to consider in rather greater detail one or two aspects of current practice and has selected to touch upon some of the problems met with in accelerating the rate of steel production when working wholly or partially liquid metal charges in the basic open hearth furnace and then to say something on the processes which have been developed to get over, with varying degrees of success, it is true, the difficulties encountered.

To render useful the large quantity of sensible heat stored in molten pig iron from the blast furnace in the subsequent refining process was a problem which invited solution in all works combining blast furnaces and open hearth furnaces on the one site on account of the great technical advantage which such a practice appeared to afford, and the experiment of employing molten pig iron in the steel furnace was tried in many instances however without yielding the results anticipated. The rate of production was but little higher than with cold charges in the same furnaces and the wear and tear on the furnace structure exceedingly heavy, and again, in taking blast furnace metal directly to the steel furnace, without any mixer or storage vessel between the two, frequent delays arose in transport and in the tapping of the blast furnace, which considerably upset the smooth working of the melting shop by causing furnaces to wait unduly for their charges and finally the virtually inevitable variation from cast to cast and from furnace to furnace in the composition of the pig metal supplied largely accentuated the difficulties met with in those early days.

In spite of these serious obstacles it was clearly appreciated that such a development must be along the path of true progress and hence with the great expansion of the open hearth process which took place towards the beginning of the present century, the problem was attacked with greater determination than had hitherto been brought to bear upon it, with a result that many modifications in working were proposed, based on more or less sound principles. At the same time the knowledge of the physico-chemical laws governing the course of the reactions in the open hearth process, such as the difference in energy change taking place in the reactions between iron ore and the metalloids in the pig iron, and the influence of temperature and concentration upon the velocity of such reaction was steadily increasing, thus placing at the disposal of the practical metallurgist the key to the solution of many problems with which he had been confronted and opening out to him many new vistas of profitable thought. Concurrently with the progress on the metallurgical side, important improvements in the mechanical appliances available were introduced, which rendered possible methods of working previously impracticable.

The introduction of the mixer into works practice at once assured adequate supplies of pig metal being available for the steel furnaces exactly when required and in a degree dependent upon its relative capacity, reduced the magnitude of the variations in composition of the metal.

The chief cause of the difficulties encountered in working liquid metal charges in the furnace and of the relatively poor output obtained was the excessive slag formation per ton of steel. Slag, although an inevitable product in most refining operations, and an essential one in the open hearth steel processes, being as it is the vehicle for the active reagents employed in the elimination of the metalloids of the charge as well as retaining in solution the oxidation products of thsee elements other than gases, is nevertheless, when in excess a great hindrance to rapid working; as not only is it a poor conductor of heat, in this way acting as an insulator between the bath and the furnace gases, but has itself a considerably higher specific heat than steel at a given temperature, thus absorbing much heat in raising it to the tapping temperature, which might otherwise have been more usefully expended in increasing the velocity of the refining reactions, hence it follows that the slag should be present in as small an amount as compatible with the performance of its chemical functions at any time during the course of the process. Mr. Bagley has stated in a valuable paper, to which reference has already been made, that taking any particular process if the slag make can be decreased one per cent, the steel make will be increased approximately 2.5 per cent, and in comparing similar practices together these figures will be found pretty near the mark.

It will be noted that the various modifications that have been put into practice for accelerating output are dependent for their success in this direction, upon the decreased slag make resulting per ton of product, or that the quantity of slag in contact with the metal at any given time is greatly reduced. In some of these processes the pig iron is diluted by either molten low carbon and highly oxidized metal, as in the well known Talbot continuous process, or by scrap steel, as is now practiced to a varying extent in many plants. In others the slag volume is diminished during the progress of the heat by pouring off a certain amount or all of it at given intervals. This may be done either when the slag has ceased to be active, i. e., when refining in stages is employed, as in the Bertrand Thiel process and its more recent modifications the Hoesch and the Dortmunder Union processes, or when it is still chemically active and far from spent, as in the Monell process. Frequently a combination of both these methods is employed, the pig being diluted down with scrap, and during the process of the heat a certain amount of slag is run off. Again, sometimes, the charge is partially refined by the pneumatic process, the slag arising therefrom separated from the metal and the latter either finished in a comparatively small fixed furnace, with or without scrap, as in the old Witkowitz process, or poured into a large bath of low carbon metal, as in current duplex practice in the States.

Having stated in general terms the principle upon which modern open hearth liquid metal processes depend it will now be well to consider more closely representative examples from practice embodying each of these three main methods available for applying this principle and the following will be taken for this purpose:

1. The liquid metal and scrap process conducted in fixed furnaces.
2. The Hoesh modification of the Bertrand Thiel process.
3. The American duplex process (combination of acid Bessemer converter and basic open hearth furnace).

Liquid Pig and Scrap Process in Fixed Furnaces.

The usual method of conducting this process is well known, so it will be unnecessary to dwell upon it at length. Briefly, some ore and lime are charged into the furnace together with the scrap, the pig metal is then poured in and the charge worked down in the usual manner with oxide and lime until the phosphorus and carbon have been eliminated to the desired extent. The slag should be as nearly as possible spent at tapping so that its action on the metal has practically ceased, that is to say the content of its active reagent, oxide of iron, should have fallen to something between 13 to 16 per cent. However, if the slag is allowed to get lower in Fe O than about 13 per cent and the ferro manganese is added in the bath there is a tendency for the carbon thus introduced to reduce phosphorus from the slag to the metal, a reaction that can only be tolerated to a very limited degree. Hence, in making a high class product it is customary to work the FeO content of the slag down to between the limits indicated and then add the greater portion of the deoxidizers in the bath and the balance of them in the ladle. In making high carbon heats it is generally the practice to work the charge down "dead soft" and then recarburize in the ladle with anthracite or cake dust. Catching the carbon on the "way down" makes greater demands upon the skill of the melter, as it is essential that the phosphorus be eliminated sufficiently before the carbon is at the required point which can only be achieved by correct bath conditions during the early stages of the heat. However, if these are obtained this method of working saves time and if the slag has not been over dosed with oxide before tapping the resulting steel will be of excellent quality.

In Tables 8 and 9 will be found particulars of four representative charges worked by this process. Table 8 contains data on the materials used in the charge, product obtained and times taken, while Table 9 gives the chemical histories of the metal and slag during the progress of the heats. It is regretted that the chemical data for the British charges is so meager, but this is accounted for by the fact that these examples were taken at random from a large number of observations on the working of the basic process under ordinary every day conditions, with a view to getting an idea of the results achieved in regular commercial practice, so that only the usual bath samples were taken as required by the sample passer.

Table 8—Typical Liquid Pig and Scrap Charges.

No. of Charge		A	B	C	D
Works Source		Julienhutte Petersen 5	Author's Notes	Author's Notes	Author's Notes
Materials charged					
Mixer metal	kg	32,100	27,430	57,915	66,000
Iron and steel scrap	kg	8,170	18,290	20.320	15,540
Limestone	kg	.....	4,570	7,112	4,065
Lime	kg	1,000	....	....	3,050
Oxide (ore)	kg	7,200	6,100	10,160	12,192
Additions during working of charge					
Pig iron	kg	.....	....	4,065	1,525
Lime	kg	1,860	7,120	9,650	12,700
Oxide (ore)	kg	765	1,525	2,030	6,600
Oxide (Roll. mill scale)	kg	.....	760	760	1,525
Finishing additions to bath					
Ferro manganese.....	kg	165	355	....	662
Finishing additions to ladle					
Ferro manganese	kg	.....	....	547	....
Production					
Good ingots	kg	39,490	45,265	85,145	88,095
Scrap	kg	970	....	....	....
Yield of good ingots..	pc	98.1	99.2	103.1	105.7
Yield of ingots, scrap	pc	100.5	....	....	....
Times					
Charging	hm	1.10	2.35	3.00	2.40
Commencement of charging to tapping	hm	5.50	12.15	14.30	19.05
Rate of steel prod'n.	kg/min	115.3	61.6	98.0	79.0
Composition of Pit Sample					
Carbon	pc	0.113	0.093	0.086	0.127
Silicon	pc	trace	0.019	0.009	trace
Sulphur	pc	0.03	0.038	0.03	0.041
Phosphorus	pc	0.034	0.028	0.028	0.032
Manganese	pc	0.45	0.43	0.47	0.45

The data on the Julienhutte charge, is however, much more complete, and as this charge is typical of good practice, the author has used it to illustrate the general course of the reactions in the basic process. To this end Fig. 11 has been prepared in order that numerous figures arrived at by observation and calculation be rendered more apparent than would be possible by tabulation.

The upper diagram, shows in the usual manner, the variation in the composition of the bath during the progress of the heat. Above these curves a temperature curve will be noted. It should be understood however that this is only approximate, but nevertheless is of great utility in bringing out more prominently the fundamental relation between temperature and the velcoity of the different reactions. It will be observed that during the early stages of the heat when the temperature is low the exothermic silicon phosphorus and manganese reactions have preference, while the carbon is attacked much more slowly. The small depressions in the temperature curve correspond to the ore and lime additions, as Dr. McCance in his brilliant work on the acid open hearth process, has found that a pronounced lowering of bath tempera-

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ture, due to absorpton of heat, takes place when these additions are made.

The lower diagram, although a work of some labor, is well worth the trouble it entails, as it assists considerably in obtaining a more precise notion of the actual distribution of the oxygen used in eliminating the metalloids at any period of the "chargdure."

The author will not pause to give an explanation of the method of calculation employed in arriving at a diagram of this nature, as those interested will find full particulars elsewhere,*14 but will pass on to consider some of its salient features. The ordinates are weight of oxygen expressed as a molicular percentage of the weight of the charge. The line a—a gives amount of oxygen at the disposal of the bath at any time. The area enclosed between the lines bc—ca and bd—d, shown crosshatched, gives the amount of oxygen in the form of FeO dissolved in the slag. As a basic slag ceases to be active when its iron content is lowered to 10 per cent, the amounts of oxygen which were in combination with iron which exceeded 10 per cent of the slag weight were ascertained and deducted from the total oxygen in the slag to give the amount of active oxygen available for doing work at any time. This is indicated by the double crosshatched area. The line bd—d shows the amount of oxygen expended in removing all the metalloids, and the line bde—e that consumed in eliminating all the silicon, phosphorus and manganese. Hence the area lying between these shows the amount required for the oxidation of the carbon.

Table 9—Chemical Histories of Charges Given in Table 8.

	Time from	Metal					Slag								
Charge	start h.m.	C. pc	Si. pc	S. pc	P. pc	Mn. pc	FeO pc	Mn pc	Al_2O_3 pc	CaO pc	MgO pc	P_2O_5 pc	S pc	SiO_2 pc	Remarks
A	...	3.610	1.21	.05	.41	2.10	....	...	...	....	...	...	...	....	Mixer metal
	1.50	...	...	...	...	...	41.3	10.56	2.40	14.86	7.14	3.50	.061	20.20	
	1.20	...	...	...	...	...	42.04	10.15	1.40	15.40	7.05	3.85	.066	20.05	
	3.15	.73	trace	.037	.066	.06	25.38	9.11	3.40	23.89	9.03	4.03	.068	24.6	
	4.05	.635	trace	.029	.048	.10	16.23	9.19	4.50	32.06	8.41	3.50	.057	25.7	370 kg lime.
	4.20	.497	trace	.030	.052	.13	13.65	8.70	4.08	34.47	7.80	3.57	.075	26.98	490 kg lime. 255 kg ore.
	4.35	.386	trace	.037	.042	.15	13.51	7.67	3.74	36.89	7.87	3.57	.068	26.70	560 kg lime. 340 kg ore.
	4.50	.272	trace	.038	.032	.14	14.73	7.50	5.06	35.98	7.80	3.71	.066	24.8	210 kg lime.
	5.00	.211	trace	.035	.036	.17	14.19	6.87	4.08	39.08	7.51	3.37	.068	23.7	170 kg lime.
	5.15	.142	trace	.03	.035	.17	13.37	7.36	3.95	39.97	7.76	3.50	.078	23.9	110 kg lime.
	5.25	.104	trace	027	.032	.19	13.24	6.87	4.22	39.69	7.99	3.37	.075	23.9	120 kg lime.
	5.40	.088	trace	.03	.029	.19	13.37	6.25	4.28	42.97	7.44	3.21	.068	21.86	165 kg ferro manganese.
	5.50	.113	trace	.03	.034	.45	12.69	7.60	4.26	43.89	6.90	3.21	.068	20.85	Charge tapped.
B	...	*	.89	.056	1.26	1.45	....	...	...	....	...	...	...	....	Mixer metal
	6.45	12	*	*	.45	*	....	...	...	....	...	...	...	....	
	9.00	...	...	...	...	...	10.4	*	*	*	*	*	*	*	
	9.48	...	...	....	...	...	13.0	*	*	*	*	*	*	*	
	10.35	.10	*	.051	.06	*	....	...	...	....	...	...	...	....	
	11.00	.10	*	.045	.045	.18	....	...	...	....	...	...	...	....	
	12.00	...	...	...	...	...	...	...	...	....	...	...	...	....	355 kg ferro manganese.
	12.15	...	...	...	...	...	...	...	...	....	...	...	...	....	Charge tapped.
C	...	*	.93	.084	1.31	1.74	....	...	...	....	...	...	...	....	Mixer metal.
	8.30	.15	*	.078	.35	*	...	...	...	....	...	...	...	....	
	9.05	.10	*	.083	.18	*	...	...	...	....	...	...	...	....	
	10.45	.12	*	.080	.10	...	9.75	...	*	*	*	*	*	*	
	11.05	...	...	...	...	...	11.05	*	*	*	*	*	*	*	
	11.30	.10	*	.056	.045	*	...	...	...	....	...	...	...	....	
	12.15	.11	*	.056	.040	*	15.6	...	*	*	*	*	*	*	
	12.55	.10	*	.042	.040	*	...	...	...	....	...	...	...	....	
	13.30	.10	*	.039	.030	.26	...	...	...	....	...	...	...	....	
	14.30	...	...	...	...	...	...	...	...	....	...	...	...	....	Charge tapped.
D	...	*	1.07	.079	1.28	1.56	...	...							Mixer metal
	9.30	1.00	*	*	*	*	...	...	...	....	...	...	...	....	
	14.45	.14	*	.074	*	*	14.3	*	*	*	*	*	*	*	
	16.15	...	...	...	...	...	15.6	*	*	*	*	*	*	*	
	17.05	.10	*	.06	.045	...	18.2	*	*	*	*	*	*	*	
	18.10	.10	*	.05	.03	.16	...	...	...	....	...	...	...	....	
	18.50	...	...	...	...	...	...	...	...	....	...	...	...	....	662 kg ferro manganese.
	19.05	...	...	...	...	...	...	...	...	....	...	...	...	....	Charge tapped.

In this particular charge, as should be the case under proper conditions, the oxygen requirements of the silicon, phosphorus and manganese were soon satisfied, while the carbon, taking only a small portion at first, rapidly became the sole consumer. It will be noticed that for the last 100 minutes the slag was practically inactive and although three small ore additions were made, it is apparent that the carbon must have reduced the ore almost immediately. It was dissolved in the slag so that the FeO content of the latter did not materially rise. This action was no doubt facilitated by the relatively high bath temperature then existing.

The Hoesch Process.

The essential difference between the Hoesch Process and the original Bertrand Thiel is that in the former the charge after tapping out is returned to the same furnace for finishing, whilst in the latter it is transferred to another furnace. Metallurgically they are exactly the same. The method of working is as follows: The pig metal is poured into the furnace on lime and oxide previously charged and the temperature is kept down. This, coupled with the very basic oxidizing slag formed insures a rapid removal of the silicon, phosphorus, and manganese, the carbon being eliminated to a much smaller extent. When the slag has become spent the charge is tapped out and the highly phosphoric slag separated. In the meantime the scrap is charged together with further quantities of lime and oxide. The metal is now returned to the furnace and the temperature is increased as quickly as possible. The carbon reaction soon sets in and feeds of lime and scale are given as necessary until the bath samples are satisfactory, when the finishers are added and the charge tapped.

Large outputs of soft steel have been obtained by this process at the Hoesch Works, three heats per day being the regular production of the 100 tons fixed furnaces there installed.[†15] The liquid iron taken from a 1,000 tons inactive mixer is, however, of excellent quality and no doubt in some measure contributes to these good results. The yield obtained is high, about 104 per cent, and the value of the very phosphoric primary slag in the basic slag in the basic slag market is considerable.

Table 10—Data on Charge "E" Hoesch Process.

Materials charged into furnace for first stage.

Mixer metal	23,280 kg
Lime	1,880 kg
Oxide (Swedish ore)	3,440 kg
Oxide (Rolling mill scale)	770 kg

Feeds during second stage—Lime 366 kg. Rolling mill scale 105 kg.
Times—Commencement of charging to end of first stage, 2.30.

Materials charged into furnace for second stage.

Iron and steel scrap	5,412 kg
Lime	1,290 kg
Oxide (Spathic ore)	2,182 kg

Finishing addition to bath. Ferro manganese 200 kg
End of first stage to end of second stage, 2.45.

Chemical History of Metal and Slag.

Time from	Metal					Slag								
start m	C. pc	Si. pc	S. pc	P. pc	Mn. pc	FeO pc	MnO pc	Al_2O_3 pc	CaO pc	MgO pc	P_2O_5 pc	S pc	SiO_2 pc	Remarks
	3.28	.032	.132	1.86	.96	....	....	...	....	...	...	...	....	Mixer metal.
60	2.47	trace	.102	.59	.17	....	....	...	....	...	...	...	....	
62	1.90	trace	.098	.47	.22	10.25	5.03	1.36	41.56	4.32	22.85	.069	12.20	
65	1.65	trace	.098	.37	.22	7.06	4.96	1.38	45.48	4.00	22.36	.124	11.80	
150	1.46	trace	.082	.26	.34	4.67	3.93	1.60	48.86	4.00	22.13	.138	11.40	Furnace tapped.
180	...	...	...	...	..	....	....	...	....	...	...	...	....	Metal returned to Fur.
230	.38	trace	.100	.090	.29	19.64	13.49	3.17	33.64	6.92	6.25	.110	14.20	
250	.205	trace	.089	.050	.23	15.78	12.08	3.00	35.78	6.70	6.70	.165	15.40	105 kg roll. mill scale.
270	.090	trace	.090	.045	.26	15.83	8.88	2.32	43.88	6.00	5.50	.289	13.20	
285	.075	trace	0.80	.035	.26	14.13	10.19	2.21	43.79	6.10	5.57	.206	14.20	160 kg lime at 295 m. 206 kg CaO.
305	.058	trace	.078	.030	.27	16.23	8.32	2.20	45.30	5.90	5.55	.275	14.00	
310	.045	trace	.077	.030	.25	17.20	7.67	2.20	46.19	6.12	5.15	.316	13.10	200 kg ferro manganese
315	.080	trace	.067	.040	.47	17.03	10.25	1.90	46.28	5.92	5.00	.344	12.40	Furnace tapped.

Production—Good ingots 29,990 kg., scrap (pit) 360 kg.
Yield—Good ingots, = 104.3 per cent. Ingots and scrap = 105.6 per cent.

Rate of steel production = 96.3 kg. per minute.

The American Duplex Process.

Perhaps one of the most striking features of American steelworks practice during the last five years or so has been the rapid growth of the duplex process. This is all the more remarkable when we remember that the only European works employing this process on a large scale, until quite recently, were driven to discard it on account of its high cost of production.[‡13] The reasons for the success of this despised tool of the old world in America are partly economic and partly technical. The huge domestic market stretching out before the very doors of American manufacturers puts a somewhat different aspect on many production problems which works on both continents have to face. In the States output is vital and technical efficiency is often of quite secondary importance especially during periods of good trade, hence the poor yield inevitable with the duplex process, and the considerable heat losses engendered by the several transferences of the metal between the different units of the plant becomes insignificant when compared to the enormous output obtainable from a combined plant. At the same time it should be pointed out that very great elasticity in operation is possible with a well laid out duplex plant, as anything from straight Bessemer to straight openhearth working, with any desired combination of the two becomes feasible, so that the plant may be run either for maximum efficiency or for maximum output, according as the market conditions warrant. Success in duplex working is vitally dependent upon the layout of the plant as with the number of transferences of metal which are necessary, and the great rapidity of working it becomes essential that the sequence of operation be absolutely unobstructed. Again with the hard driving which is such a characteristic feature of blast furnace practice in the States it has always been difficult to obtain pig metal low enough in silicon to treat profitably in the open-hearth furnace unless diluted with a considerable percentage of scrap. Scrap, beyond that produced within the works, has been increasingly difficult to obtain in sufficient quantities of late years, especially in the great centers of steel industry. The duplex process provides a means of solving this problem. In the words of Mr. T. W. Robinson, vice president of the Illinois Steel Company, "Steel scrap or its equivalent is an economic necessity for the straight open-hearth process, but the underlying cause of the growth of the duplex process is its independence of a steel scrap supply."[§]

In the American duplex process the acid Bessemer converter is used for desiliconizing and decarbonizing and the basic open-hearth furnace for dephosphorizing. By this means instead of carrying out a complex series of reactions in one furnace, which, while it may be capable of performing some of the reactions well, it cannot do so for all employs, the acid converter for eliminating silicon and carbon, both of which functions it is well suited for, and finishes the blown metal in the basic open-hearth furnace. The latter is thus fed with an iron containing no silicon and a little carbon and it is called on only to eliminate the phosphorus and the remainder of the carbon for which purpose it is well adapted.

To dwell at length upon the acid Bessemer stage of the duplex process would be outside the scope of this paper. Suffice it to say that the converters are

Table 11—Particulars of Equipment at Representative American Duplex Steel Plants.

Location	South Bethlehem	Lackawanna			South Chicago		Sparrows Point	
Mixers								
Number	2	1	1	2	1	300	1	1
Individual capacity ... tons	400	250	300	1300	1300	300	1300	250
Converters								
Number	2		4	3		2		4
Individual capacity ... tons	20		12	25		25		30
Fixed open hearth furnaces								
Number	10		8	..		..		..
Individual capacity ... tons	60		100	..		..		..
Tilting open hearth furnaces								
Number	..		2	3		3		4
Individual capacity ... tons	..		200	200		250		200
Ladle cranes in mixer building								
Number	1		1	1		1		1
Individual capacity ... tons	60		100	75		100		100
Ladle cranes in melting shop charging bay								
Number						3		2
Individual capacity ... tons				100		100		100
Ladle cranes in melting shop casting bay								
Number						2	1 2	2*
Individual capacity ... tons				175		175	100 175	40
Method of transporting metal between mixers and converters	E.O.T. Crane		Electric Haulage	Electric Haulage			E.O.T. Crane	
Method of transporting blown metal to open hearth furnaces	Loco ladle		Loco ladle	Loco ladle			E.O.T. Crane E.O.T. Crane	

*These cranes are for general "pit side" duties.

usually of large capacity—up to 30 tons in some instances—but otherwise do not present any features different from those employed in current straight Besemer practice. In operation, these large vessels, as a result of their lower radiation losses, have a marked tendency to blow "hot" with consequent high residual silicon content in the metal after decarbonization, which can only be got rid of at the expense of considerable oxidation of iron, thus diminishing the yield.

In so far as the open-hearth stage is concerned, the process as now carried out in large tilting furnaces of 200 to 250 tons capacity is practically the Talbot continuous process using refined iron. It may be of interest to briefly describe the working of a charge in one of these large furnaces. After the previous heat of, say 100 tons, has been poured out, the greater portion of the slag being retained in the furnace, the side walls along the slag line are repaired. Lime and ore are charged, the flame turned on and a basic and highly-oxidizing slag soon formed. Orders are then given to the Besemer department for the number of vessels required for the heat and as blown the Bessemer metal, cleaned of its silicious slag, is poured into the open-hearth furnace. The last Bessemer charge, or "kicker" as it is termed, is but partially blown, having about 1 to 1.5 per cent of carbon in the metal. Immediately upon the introduction of the "kicker" into the molten and highly oxidized bath a vigorous boil takes place, the slag frothing up and pouring out of the notches in the door sill plates. The violent ebullition of the bath assists much in bringnig the slag into intimate contact with the metal and the oxidization of the phosphorus is rapidily accomplished, if the temperature is not too high, and much of it passes out of the furnace in the slag. When the boil has subsided a metal sample is taken and the bath worked down accordingly. If the carbon is still high a further ore addition may be made, or if the phosphorus has not been eliminated far enough more lime may be necessary. When ready the heat is teemed and the recarburizer and ferro-manganese, or spiegel iron, are added in the ladle.

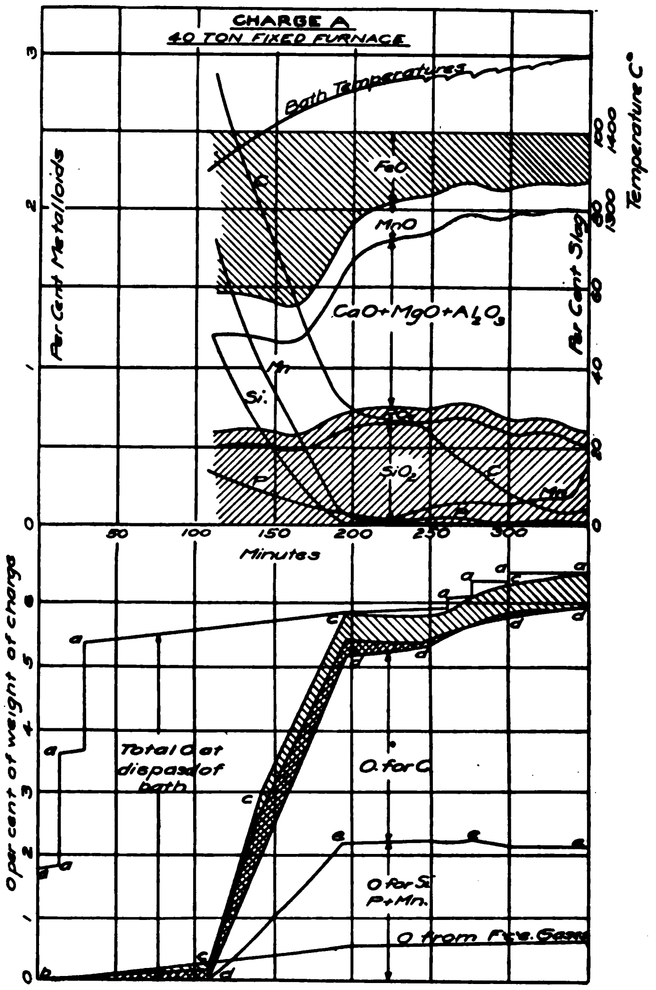


Fig. 1.

It is of great importance that the phosphorus be quickly attacked and removed to the desired extent before the carbon is all out. If much elimination of

(Continued on page 236)

Fitting by Forcing or Shrinking

In Machine Construction and Repairs These Methods of Holding Wheels on Shafts Have Proven More Satisfactory Than That of Using Keys.

By **W. S. STANDIFORD.**

IN the realm of machine construction and mill repairs, the importance of holding wheels on shafts by means of a forced fit instead of the usual method of securing the parts to be held together by means of a key, does not seem to be used to the extent that it should, considering the excellent results obtained with gear wheels, etc.; that are subjected to heavy vibration. Pinions held on the ends of shafts by a key will not stand jarring for any length of time, as sooner or later they cause trouble by getting loose and coming off their shafts. In cases where the shaking and pressure exerted upon a pinion is continuous, the latter will remain fast upon its support for a much longer length of time, than where the motion is intermittent and jerky as the heavy thrust and leverage soon forces out a key.

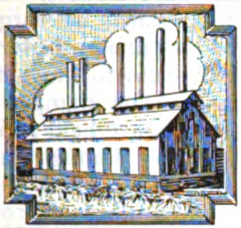
Two keys, put upon a quarter circle from each other will enable a pinion to remain longer on a shaft; but the writer has found out by experience, that where continuous running machinery is desired, and giving the least amount of trouble to a factory's repair forces, it is much better to force a gear wheel on a shaft by hydraulic pressure, no key being needed in this case, as a pinion or gear wheel pressed on in this manner will remain until it requires to be removed by reason of worn teeth; removal being easily and quickly effected by cutting a slot in the bottom of a tooth and forcing a wedge in slot and knocking the wheel off with a hammer. In making press or forced fits, the part that is to be driven, must of course, be larger in diameter than the hole which receives it, but the difference in regard to such press fits is not so great as some machinists think should be the case, as all that is needed is to have the grip between the two metals sufficiently tight so as to prevent the parts from coming off. Any heavier pressure used for work of this character puts a strain upon the metal around the hole that will cause a cast iron pinion to break suddenly while it is in action. The usual practice among machinists in doing work of this kind is to judge the proper amount of oversize allowance by the feel of a calipers; but this is a very uncertain method as errors are likely to be made in judging sizes.

The right way of taking such measurements is by means of an inside micrometer calipers used in the hole, and an outside micrometer calipers to find the shaft size. This puts all measurements upon an exact basis, the worker knowing at all times just what allowance has been given in thousandths of an inch, instead of a slipshod caliper feel, and its guesswork as to the proper amount of oversize required. A mechanic always gains by doing all work, whatever its character may be, as carefully as possible as bad habits once formed in doing work are hard to break and often lead to spoilt work. There is a limit to the sizes of articles made with forced or pressed fits, which is due to the fact that as the diameter of a shaft and hole in a pinion increases, more powerful hydraulic apparatus is required to press them together; so that a point is soon reached where it would not pay to keep an expensive and powerful machine around a shop for only occasional use.

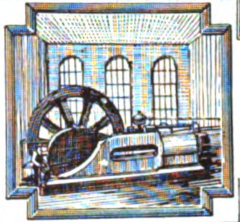
As a general rule, force fits are mostly made on such small objects as crank pins, car wheel axles, machine construction and other repair parts that require to be held securely. In judging the proper allowance for a press fit, several factors have to be taken into consideration, viz.: The thickness of metal surrounding the hole, kind and quality of material of which the parts are made, the size of the work and also smoothness and accuracy of bore and shaft that are to be fitted together. However, as a general rule, to make a press fit of the greatest possible strength, there should be a difference in the sizes of the parts to be fitted, of from two to three thousandths of an inch—for each inch of diameter of the article. The following formula will serve to give an idea of the pressure in tons required for making forced fits for different shaft diameters. The required pressure in tons will be the fit allowances in thousandths of an inch multiplied by the diameter of shaft in inches and also by the factor of 1½.

As an example. Suppose that a gear wheel is to be forced on a 5-inch shaft, the press fit allowance being .002 for each inch of diameter. 5 × .002 = .010 the latter being the allowance, and the pressure in tons will be 10 × 5 × 1½ = 75 tons. On smaller diameters of shafts where an extra heavy grip between the parts are desired, the larger figure of .003 inch can be used. Take the case of a 2-inch shaft; 2 × .003 = .006 the allowance, and the pressure in tons will be 6 × 2 × 1½ = 18 tons. It will be apparent to the readers of this magazine, that if the allowance figures given in both of the above cases, were adhered to for large sized shafts, that the necessary pressure would be very great and beyond the appliances found in most shops. To show this clearly, we will suppose that a 15 inch crank pin is to be fitted into its disk. Using an allowance of .002 inch × 15 inches = .030 multiplying 30 × 15 × 1½ = 675 tons pressure needed to do the work. Very few large factories possess the facilities for obtaining such heavy pressures, which make extra tight fits that are unnecessary, as all that is required is to make the parts hold together. In practice, for a shaft of 15 inches size, it will be found that an .010 inch press allowance will be sufficient, the tonnage necessary to force them together being much less. Some mechanics taper the parts to be fitted together thinking that tighter fits will result, this is bad practice, because the tendency of taper fitted parts to become loose under vibration is always present, and once it loosens, the entire fit frees itself, it taking very little axial movement to do so On the other hand, a taper fit does not abrade the surfaces of the parts pressed together, to the extent that a level fit does. In order to prevent abrasion in work of this kind, it is advisable to lubricate the surfaces with white lead mixed with a little lard oil, as it is best to keep the surfaces as smooth as possible, so as to allow for renewing gears, etc., on the same shaft when they are needed.

(Continued on page 236)



STEAM POWER DEPARTMENT



Installation of World's Largest Boilers

Description of Large Boilers Operating at the River Rouge Plant of the Ford Motor Company—Description of Superheaters and Powdered Coal Equipment.

By GEORGE T. LADD.

A DESCRIPTION of a plant or apparatus which has not been entirely completed must necessarily be limited to construction features. Much interest, however, has been shown in the construction details of the new power house at the River Rouge plant of the Ford Motor Company and it is with these details as applied to the boilers that this paper deals.

The power house itself consists of an east wing housing the turbo generators, a large bay at present constructed to receive eight boilers, four of which are now in place, and a west wing housing the turbo blowers for the blast furnaces. Steam will be generated at 240 lbs. pressure and superheated 200 degrees.

The boilers are of the five drum type, four steam and water drums and one top seam collector drum, with the tubing installed as shown in Fig. 1. The top steam drum is provided with two 10 inch nozzles, each of which is connected to one of the outside or saturated headers of the superheater, so that the course of the steam is from the relieving surfaces in the two main top drums, up through the steam connectors to the steam drum, thence down into the outside superheated headers, through the superheater elements and back to the central superheater header, one end of which constitutes the boiler outlet nozzle.

The floor space occupied by each unit is somewhat less than might be expected, being but 29 feet 0 inches by 31 feet 0 inches column centers. The furnace, while irregularly shaped, is approximately 23 feet 0 inches by 24 feet 0 inches inside by 55 feet 0 inches high above the ash pits. The combustion space allowed by this furnace, exclusive of the ash pits, is about 5 cubic feet per normal rated horsepower. The total height of the boiler from the ash pit floor to the top of the superheater piping is 82 feet 9⅞ inches.

Mounted over each boiler, and supported by the building framing, is a brick lined steel stack 11 feet 0 inches inside diameter, with the top reaching 327 feet above the ash floor level. Space is left between the top of the boiler and the base of the stack for the introduction of economizers, but these will not be installed until a future date.

The complete structure of the boiler, superheater and setting is supported entirely on the building steel, the total weight per unit being approximately 2,250,000 pounds. Some idea of the enormous amount of material contained in these four boilers can be had from the fact that, exclusive of the building supporting steel, superheaters and stacks, it required 110 cars to transport the material for the four boilers and settings. Shipments of material were started September 11, 1919, and the first boiler was completed and in service on October 1, 1920, with the balance going into service at intervals of approximately 30 days each.

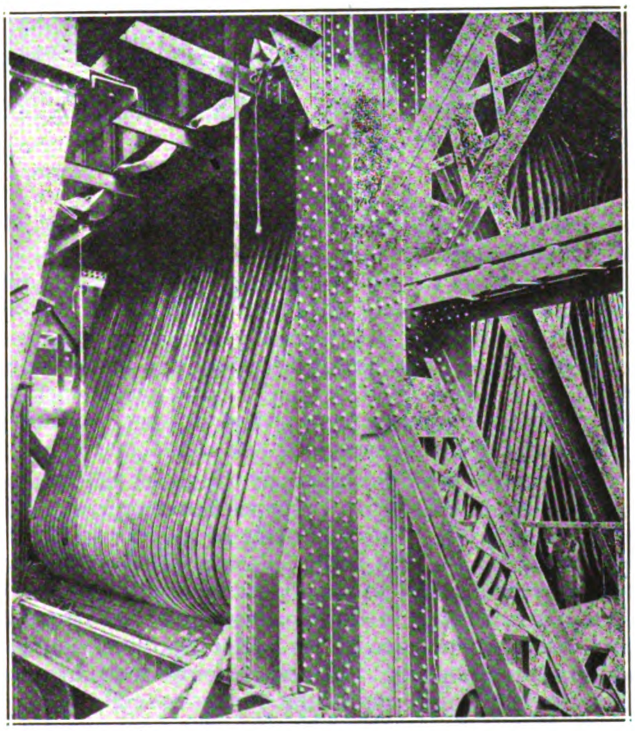


Fig. 1—Nest of boiler tubes.

The large main drums are 5 feet 0 inches inside diameter by 25 feet 10¾ inches long with 1 5/16 inch thick

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Abstract of paper presented before Engineers Society of Western Pennsylvania, entitled, "Description of Large Boilers Operating at the River Rouge Plant of the Ford Motor Company, complete paper and discussion will appear in April proceedings of that society.

shell plates. The shell is constructed with a top and bottom plate, both continuous, fastened with double riveted butt joints, with all rivets, both in the butts and head seams 1⅜ inches in diameter. All connections to the drums are either flanged or expanded. Each of the main drums is drilled for 738 tubes exclusive of the water balancing tubes connecting the top main drum and the tubes connecting with the steam collector drum. The top drums are also fitted with the main hangers, each of which consists of two ¾ inch web plates bolted to cast steel pads rigidly riveted to the top drum plates.

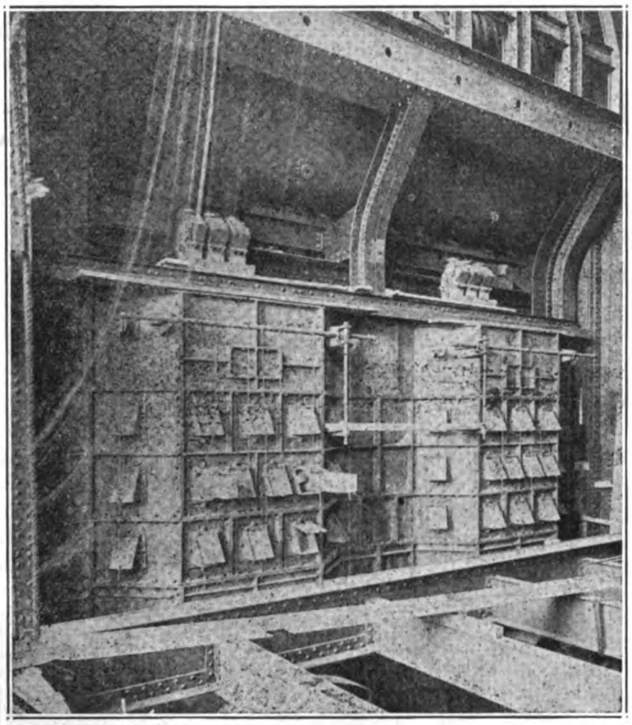


Fig. 2.

Each half of the boiler contains seven rows of tubes in the front pass, six in the middle and five in the rear. The tubes are spaced longitudinally, with such dimensions as to allow for easy removal and at the same time to admit of the introduction of the superheater elements, also allowing ample space for the passage of flue gas without too greatly increasing the draft loss.

In the previous description of the drum details, mention was made of the main suspension hangers. While these hangers are riveted securely in position on the top drums, the load of the boiler is transmitted to the overhead supporting steel in such a manner as to prevent expansion strains due to the elongation of the drums and the consequent increase of the center to center dimension between the supports. This is accomplished by means of the toggle connection on the expansion end.

The principle of this device is clearly shown in Fig. 3. The main pin, designed for bending, transmits the load from the hanger web plates to the toggle, which swings inside the box girder suspension beam. This bin is securely seated in the toggle itself so that any longitudinal motion of the drum causes the pin to move freely through the large holes in the web plates of the box girder, transmitting its motion to the toggle which, in turn, swings like a pendulum from the pin, mounted above the suspension beam.

In addition to the flexibility of the suspension, a great deal of attention was given to all other parts of the boiler where expansion strains might cause trouble. The position of the lower drums is maintained by forged head lugs bearing on lugs riveted to an outside girder in such a manner as to allow the lower drum to move freely in the direction of the main axis. The damper frames, which are 26 feet 9 inches in length, are held rigidly only at the center, and are fitted with three damper leaves having shafts with squared ends carried in spools which ride on rough roller bearings mounted in cast iron boxes bolted to the frame. This construction allows the three leaves to be actuated as one member and gives six points in the total damper where expansion may take place and results in a practically gas tight, freely moving mechanism, over a wide range of temperature.

The boiler is baffled for three gas passes, giving a total length of gas travel through the tube area of approximately 50 feet 0 inches. The baffle openings have not as yet been changed since the original design and no data is at hand which will warrant the assertion that the areas as installed will be adequate for the highest ratings that will ultimately be required. The evidence so far, however, points to the development of between 6,000 and 7,000 horsepower without excessive draft loss.

The main side walls of the boiler rest on heavy double girders framed into the building columns, having a top elevation of about 8 feet 0 inches above the ash pit doors. From the top of this girder, or the footing of the side walls to their top, is 48 feet 2¾ inches. There are two offsets in this wall which change it from a total thickness at the base of 33¾ inches to 22½ inches at the top section. A plan shows the inner face concaved to a depth of 9 inches for the lower two-thirds and to a depth of 4½ inches in the upper section. The lower sections are lined with a minimum of 13½ inches of first quality firebrick and the upper section with 9 inches. Between the firebrick and the face brick a 4½ inch insulating course of Cil-O-Cel brick was used, except in the zone of highest temperatures where it was omitted on the theory that preventing the radiation at this point might prove injurious to the firebrick lining. (See Fig. 4). There are three relieving arches in each side wall so placed as to provide for the repair of any spot in the high temperature zone.

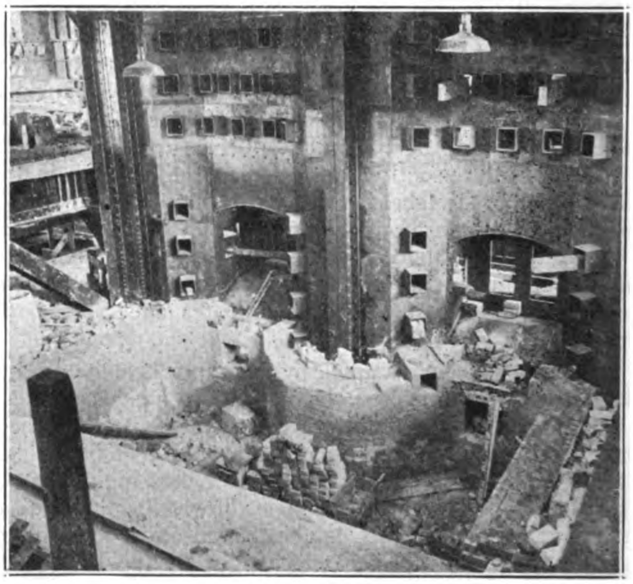


Fig. 3—The boiler under construction.

The position of these arches can best be seen in Fig. 1.

All steel members passing the face of this wall are designed with their inside surfaces theoretically in the plane of the outside surface of the brick, but in the case of the deeper girders the face brick was set back to allow a 4½ inch air space between the steel and the setting, thus completely air cooling these members.

Since starting the boilers, the furnace action on this wall has been very carefully observed. At the beginning there was a slight indication of longitudinal expansion visible at the corners, but this did not exceed one-quarter of an inch. Aside from this movement no defects have been noted and at the present time the brickwork apparently is in as good condition structurally as on the day it was finished. The heat action has thoroughly glazed the life of this detail.

The main supporting girder carrying this wall was designed with extreme care, the proportion of load on each web carefully computed and diaphragms used in an effort to cause both webs to deflect alike. It was also made extremely heavy and the deflection kept as low as possible.

The mixing oven furnace wall shows in plan as a W-shaped structure. It is also supported entirely on the building steel, but its height and weight is considerably less than the side wall. It is built with a batter on the inside, the latter being three-eighths of an inch to one foot, and is lined with 9 inches of first quality brick and insulated with Cil-O-Cel. On the outside there is a continuous cast iron jacket having the same contour as the wall itself, which supports the air doors through which the induced draft to the pulverized fuel is delivered. This jacket also supports the small Dutch ovens into which the blast furnace gas burners are introduced. The combined area of the air openings through the two walls of each boiler is about 60 square feet.

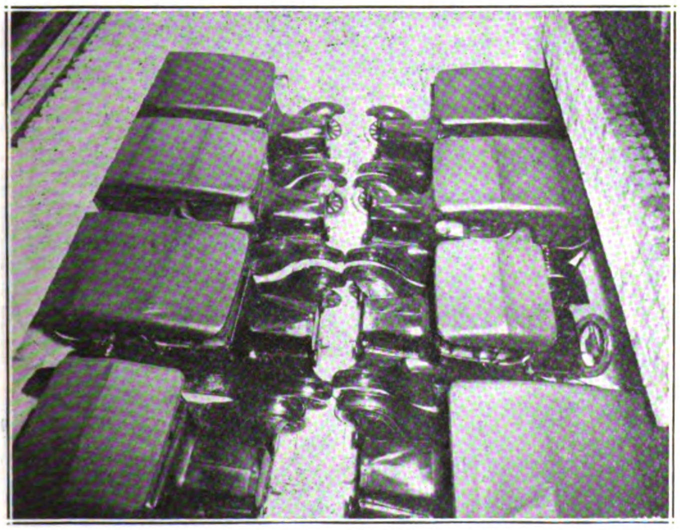


Fig. 4—Eight Ford cars in the boiler.

One of the most difficult features on the entire structure was the support of the main arches through which the pulverized fuel burners are introduced and which seal the setting from the burner elevation to the front side of the lower drums. These arches are 23 feet 0 inches in length, overhang the furnace about 4 feet 0 inches and are 9 feet 0 inches high from the bottom of the overhang to the top. A suspended arch construction was used throughout, i.e., moulded blocks of firebrick hanging on cast steel arch bars. Practically the entire load of the arch passes into the main supporting arch girder near its bottom chord, the top girder serving largely as a resistant to the tendency of the arch structure to topple over into the furnace.

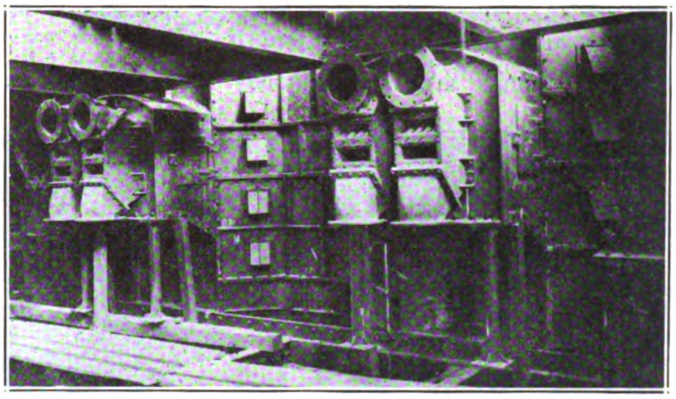


Fig. 5—Blast furnace gas connections.

Such a loading is necessarily extremely eccentric, but this was cared for by a rather complicated system of bracing over the top of the horizontal portion. The supporting girders were made very heavy, the unit stresses being kept down to 4,000 to 5,000 pounds per square inch. Resting on the horizontal framing are the sheath castings through which the pulverized fuel burners are introduced, one over each section of the "W" mentioned in the description of the mixing oven furnace wall.

Cast steel was selected as the best material for the arch bars on the theory of its longer life under severe heat action. These castings are introduced on six inch centers the entire length of the arch, that is, between each course of firebrick blocks.

The severe strain of the eccentric loading of the arch brick was greatly modified by utilizing the center front buckstay in such a manner that the supporting girders are held back to this member at their center, cutting their span of 29 feet 0 inches between the supports into two parts.

I have already indicated the position of the blast furnace gas burners. Four double burners are used, placed vertically below the pulverized fuel burners and introduced into the fronts of the small Dutch ovens built out from the lower portion of the mixing oven furnace wall. The furnace end of these small Dutch ovens is 24 feet 0 inches below the nearest point in the heating surface so that from the mouth of the burners to a point in mid-furnace, halfway between the lower drums there is a flame travel of nearly 30 feet 0 inches. This point is mentioned particularly on account of the interest to this community of furnace construction for the burning of blast furnace gas under boilers. There has been a marked tendency in Pittsburgh to increase the size of such furnaces and we believe that when the final results are available on the Detroit Boilers it will be shown that even for the burning of gas alone the furnaces in question are not too large.

The blast furnace gas burners are of the forced draft type, subdivided by vertical vanes so that the gas and air is introduced in thin vertical layers, the gas and air alternating. A system of regulating the air pressure to suit the gas pressure is being worked out and is apparently meeting with success.

The two sides of the boiler over the pulverized fuel burners and extending from the lower drum to the damper box are incased with removable casings. Six points were attempted in this construction:

1. Pleasing outside appearance.
2. Rigidity.
3. Tightness or freedom from air leaks.
4. Easy accessibility.
5. Safety in case of accidental high temperatures.
6. Heat insulation.

The casings are approximately 23 feet 0 inches square, so that in order to present a smooth external panelled appearance it was necessary to give considerable thought to the main ribs or supports. The method finally adopted was to use hollow air cooled members placed on 3 feet 5 inch centers and reaching from the bottom supporting girder to the top. These ribs are faced on the outside with a plate and angle construction so assembled as to provide a ledge against which the thin casing plates rest. These plates are plain rectangular sheared plates without punching and are held in place by outside jamb angles with mitred corners. There is ample clearance on the ledges, so that there is no possibility of accumulative or creeping errors. To remove the plates it is only necessary to take off only the exposed bolts on the outside.

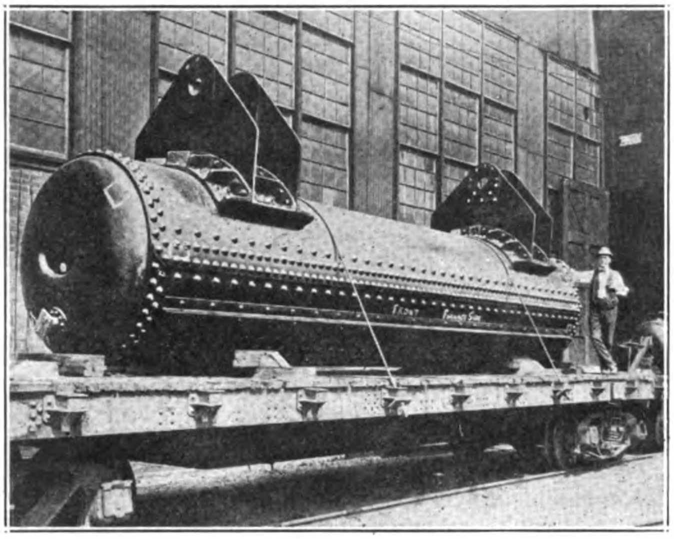


Fig. 6—Under shipment.

Surrounding the ribs on the inside and interlocking with the panel tile are special firebrick shapes which entirely face the inside of the casing with a firebrick lining about 5 inches thick. Between these tile and the casing plates a layer of Cil-O-Cel brick was introduced.

With the exception of the ribs there is no single piece in the casing weighing over 150 lbs. which, coupled with the facility for reaching it from the outside of the boiler, makes it possible to throw open any panel or the entire casing from top to bottom within a very short time. It has proven impervious to any discoverable air leaks, shows no signs of heating up, maintains its alignment and offers a smooth workmanlike appearance on the outside.

The ash pits and entire furnace bottom are suspended from the same girder that carries the main side wall. It will be noted that the central portion is arched longitudinally with the setting and the brick so constructed as to divert ash or dust falling from the flame zone into a hopper formation at each corner of the furnace. Each of these hoppers is equipped with a 4 foot by 3 foot sliding ash gate. A standard gauge track passes underneath the arched portion while two special ash tracks pass under the ash grates, providing a vertical discharge for refuse.

From time to time many questions have been asked concerning provision made for the expansion of the brick in these furnaces. The answer to this is that no provision was made at all, for under continuous high temperatures first quality fire clay brick contract rather than expand. The concave form of the inner face of the main side walls was put in to act as an arch against so-called tendency of the brick to creep toward the flame after shrinkage had taken place. We are aware that in some boiler settings expansion joints have been provided in brick walls having a large expanse, but we have always maintained that there was not sufficient expansion in fire clay brick and the other grades of brick entering into a boiler setting to make this necessary. It is essential that all steel supporting members subjected to heat be free to move in the direction of the long axis and that as much flexibility as possible be provided in the structure as a whole, but with this provision we do not regard the providing of expansion joints in the brick walls as necessary. It is quite possible that a little expansion occurs when the furnace is first heated up, but in the structures in question the general flexibility of the frame was sufficient, and had we the design to make over again we can see no reason why it should be changed.

The two fuels that have been used are blast furnace gas and tar, but it is the ultimate intention to burn the entire amount of blast furnace gas available, taking any load beyond this with pulverized coal. It has been estimated that for the night load the gas will be sufficient, but a considerable quantity of coal will have to be burned during the day to obtain the ratings desired.

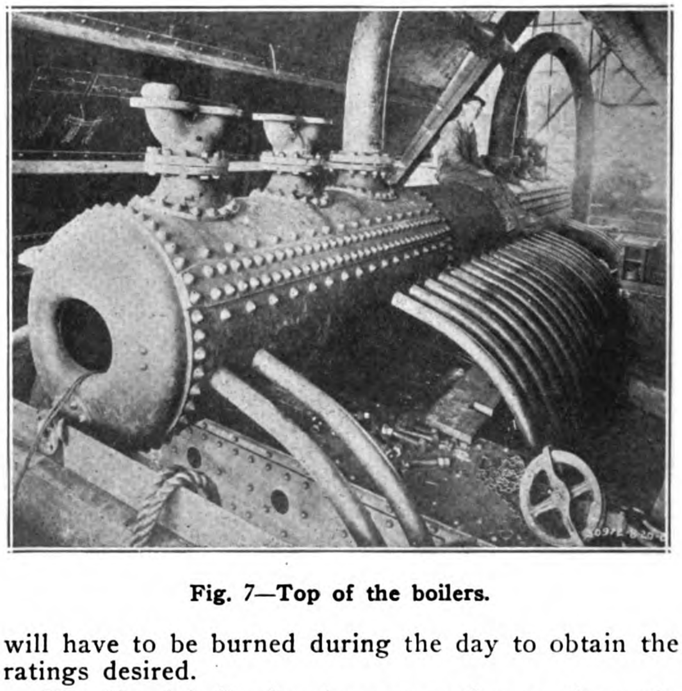


Fig. 7—Top of the boilers.

The No. 1 boiler has been operating continuously since October 1. It was started with gas alone and with a somewhat temporary and inadequate air supply for the gas burners developed, as near as could be estimated, nearly 175 per cent of rating. This matter was arrived at through the proportion of the load of the temporary boiler plant assumed by the No. 1 boiler. Later, tar burners were introduced near the bottom of the setting to further increase the rating and for one interval at least the whole load of the temporary plant was thrown on this unit. The temporary plant develops normally about 6,000 or 7,000 horse power and the No. 1 boiler assumed this entire load under the combined gas and tar firing, without difficulty. This data is not offered in any way as test evidence, but merely as a matter of interest pending further determinations.

The furnace action is particularly gratifying. The temperature developed by the tar shows with an optical pyrometer about 3,100 degrees at the end of the flame, but no severe action has as yet been noted on the brick.

Description of Super-Heaters.

The problem presented to the super-heater engineer in designing super-heaters for this installation was very exacting. The unusual arrangement of the boiler, the enormous size, the high pressure and super-heat specified, presented many difficult problems to overcome. A number of different designs were proposed, but the construction outlined below and illustrated in the slides, was selected because it seemed to best meet the peculiar conditions of this particular plant.

General Construction.

Each super-heater consists of three heaters, two 10 inches in diameter and one 12 inches, all approximately 23 feet long, together with the connecting elements.

Headers.

All three headers are located on top of the boilers, immediately above the steam generating drums, and below the steam collector drum. With this arrangement the super-heater headers with the unit joints, are placed entirely outside the hot gas bath and are accessible to inspection without entering the setting, even during operation. This is a highly important feature, particularly in large boilers which are kept in operation for considerable periods without shutdowns.

The 12-inch super-heated header is located in the center and the two 10-inch saturated headers one on each side. They are made of open hearth steel pipe, in accordance with A. S. M. E. specifications. The flange connections at each end are VanStone joints using extra heavy forged steel flanges.

A cross section of the headers is illustration in which shows the special joint construction. The connection between the units and the headers is of special interest because of the absence of expanded joints. The ends of the elements are upset forming a ball joint, the face of which is ground to a true sphere. The corresponding seat in the header for this ball joint is ground to a conical shape, thus forming a solid metal to metal contact, which is kept closed by means of a heavy clamp and bolt construction. The clamp rests on a unit washer, also ground to a spherical contour, making possible the self-alignment of the entire joint. The bolt is made of chrome nickel steel, having an ultimate tensile strength of not less than 100,000 pounds per square inch.

In general super-heater design there has been considerable controversy over the question of the relative position of the super-heater headers to the units. This controversy revolves mainly about the subject of drainability of the units. It is our contention that here reasonably pure feed water is used and the super-heater is designed to give a relatively high steam velocity through the units there there is no need to drain the elements, and by locating the headers at the top of the boiler all the joints are placed entirely away from the action of the hot gases. The top header construction also gives easy access to the joints at all times and facilitates the easy removal and replacement of any unit without entering the setting.

While there are undoubtedly cases where, due to local conditions, bad water, etc., it is advisable to build the super-heater with drainable units, where conditions are reasonably favorable we believe the advantages of the non-drainable type make it much to be preferred.

Powdered Coal Equipment.

The work done by our company on the River Rouge boiler plant covers the design and installation of the pulverizing plant and conveying system from the pulverizing plant to the boiler room and the design and equipment of the boiler furnaces.

Coal crushed so that it will pass a one and one-quarter inch ring is furnished to the overhead bunker —from the coaling station at the coke ovens. This overhead bunker has a storage capacity of 700 tons, which is equal to 17 hours storage with all four boilers operating exclusively on coal at 250 degrees rating.

The plant is at present equipped with four Raymond air separation mills of six tons capacity each. The coal is fed to these mills by gravity direct from the coal bunker through cast iron pipes and fed into the mills automatically in pre-determined quantities.

The coal, having been pulverized to a fineness so that 84 per cent will pass a 200 mesh screen is taken from the mill by air and gathered in the centrifugal collectors, from where it is discharged into 80 foot elevators, which deliver it into screw conveyors at a proper height for distribution to the top of the boiler bins. From the boiler bins it is fed to the furnaces by standard Lopulco feeders, of which there are 12 to each boiler, and through the standard Lopulco triplex burners, of which there are four to each boiler.

About 10 per cent of the air for combustion enters with the coal as the carrying medium from the feeder. The remainder of the combustion air entering through the air ports in the burner and through the auxiliary air openings in the front of the furnaces.

A study was made of the various systems being marketed for the burning of powdered fuel and it was finally determined to use the Lopulco system.

NEW COMPANY TO MAKE FERROZIRCONIUM.

The Industrial Bureau, Board of Trade, Baltimore, Md., has announced that the Zirconium Company of Amreica has acquired the plant of the Baltimore Rubber Tire Mfg. Co., Monument and Eleventh streets, Baltimore, and will manufacture ferrozirconium, and zirconium oxide. The property acquired consists of six buildings. The officers of the company are George F. Dixson, president; Philip C. Spencer, vice president; Charles W. Smiley, secretary, and Morris Meyer, treasurer.

Development of The Steam Turbine

General Classification of Steam Turbines in Relation to Their Special Characteristics—Respective Advantages of Impulse and Reaction Turbines.

By **ROBERT JUNE.**

PART II.

IT is not a very satisfactory proceeding to attempt a general classification of steam turbines because the various groups overlap to a considerable extent. However, there are sufficient differences in the characteristics of a number of well known turbines so that they may be conveniently classified according to the fundamental principles involved in their operation, as follows:

Impulse				Reaction	Combined Impulse and Reaction
Single Velocity	Multi-Velocity Stage	Single Velocity Stage	Multi-Velocity Stage	Multi-Velocity Stage	Multi-Velocity Stage
DeLaval	Terry Sturtevant Curtis (small type) Westinghouse	Kerr DeLaval Rateau	Curtis	Westinghouse-Parsons Allis-Chalmers Parsons	Westinghouse
Single Pressure Stage		Multi-Pressure Stage			

Impulse Turbines.

In turbines of the impulse type the complete expansion takes place in the stationary blades or nozzles and the steam is delivered to the moving blades with a velocity somewhat more than double that of the blades. The velocity of the jet is very high, from 2,000 to 4,000 feet per second, and for satisfactory economy the peripheral velocity of the wheel must also be very high. The passages between the moving blades are of uniform or even slightly increasing cross-section from inlet to outlet. The moving blades check and reverse the velocity of the steam current, thus creating a force against the blades which sets the rotor in motion.

If the entire pressure drop takes place in one set of nozzles and the resulting jet is directed against a single wheel, the turbine is classified as belonging to the single stage, single velocity group, of which the DeLaval class "A" turbine is a well known example.

We have just stated that for satisfactory economy the peripheral velocity of the wheel must be very high in turbines of this sort. However, it is possible to use a lower speed rotor by compounding the velocity. When this is done the jet issuing from the nozzle at a very high velocity is reflected back and forth from the vanes on the rotor to a series of fixed reversing buckets until all the available kinetic energy of the jet has been imparted to the wheel. An excellent illustration of this type of turbine is the Terry single stage machine.

Other means of combining low peripheral velocity and high efficiency is through pressure compounding. When this is done, expansion takes place in a series of successive nozzles instead of one nozzle. Thus, only a fraction of the available heat energy is converted into kinetic energy in each nozzle. For each set of fixed nozzles there is a corresponding rotor. To all intents and purposes this type of turbine consists of a series of single velocity impulse turbines placed side by side.

If we compound both velocity and pressure we have the multi-velocity and pressure type of which the Curtis turbine is the best known example.

Reaction Type Turbine.

In the reaction turbine, approximately one-half of the expansion in any one stage takes place in the stationary blades, imparting to the steam a velocity substantially equal to that of the moving blades so that it enters them without impulse. The remainder of the expansion takes place in the moving blades, the spaces between which gradually grow smaller from inlet to the exit side of the turbine, thus forming a ring of moving nozzles. The velocity imparted to the steam by reason of the expansion occurring in the moving blades produces a reactive force on these blades which turns the rotor of the turbine.

Only a very small portion of the heat energy imparts velocity in the first set of fixed blades or nozzles. As the expansion is very gradual a large number of alternate fixed and revolving blades are necessary to effect complete expansion.

Combined Impulse and Reaction Turbines.

In multi-stage work it has been found that the use of an impulse element for the first stage of expansion and the use of reaction elements for the subsequent stages forms an effective combination. The impulse element replaces without any appreciable sacrifice of economy a considerable number of rows of reaction blades in the least efficient part of the reaction turbine, and makes possible a shorter, and consequently, stiffer rotor. The Westinghouse-Parsons double flow high pressure turbine is typical of this class.

Respective Advantages of Impulse and Reaction Turbines.

The impulse and the reaction turbines represent two schools of engineering development, each of which secures practically the same result as the other, but by slightly different means. It is fully as difficult to compare the advantages of one type of turbine over the other as it is to compare the respective advantags of horizontal and vertical water tube boilers. While many engineers can offer excellent reasons for preferring one type of turbine over the other, the fact remains that to a great majority of engineers these reasons are comparatively unimportant, and their preferences will depend not upon general considerations, but upon the conditions obtaining in their individual plants.

It is plain that in the impulse type, because of the considerable differences in pressure which exist between adjacent stages and the fact that steam leakage increases as the square of the pressure drops, that it is very important that means be devised to minimize the leakage and result loss of efficiency. It has, therefore, been the universal practice with this type of turbine to employ a rotor built up of disks mounted on a shaft of small diameter in order that the clearance between the shaft and the diaphragm separating the pressure chambers may be as small as possible. This construction results in a light shaft which may develop deflection seriously. It is also claimed that the disks of the impulse turbine are subject to frequent temperature changes, and because of these changes and the high velocities at which the turbine operates, the disks are to some degree liable to rupture.

An advantage claimed for the impulse turbine is that because the blades are very much larger and very much fewer in number than the reaction blades, that there is considerable less difficulty in maintaining them.

For the reaction turbine it is claimed that the rotor, being made up of a comparatively thin cylindrical drum of considerable diameter with rings of large bore, that the internal strain in the disks is negligible. It has also been said that the drum construction of the rotor makes the reaction turbine very much more accessible for examination and repair.

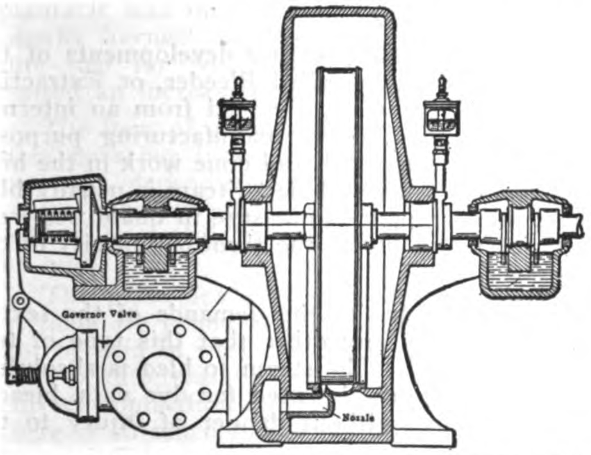


Fig. 1—Section through single-stage Terry steam turbine.

It is well to remember, however, that the several types of turbines are made by concerns of the very highest standing in the engineering world, and this fact may be practically considered as a guarantee of the successful operation of the turbines produced by these manufacturers.

Terry Non-Condensing Turbine.

In the Terry non-condensing turbine, Fig. 1, courtesy Gebhardt, the compounding of the velocity permits of much lower peripheral velocities than with the single velocity type. The rotor, a single wheel consisting of two steel disks held together by bolts over a steel center, is fitted at its periphery with pressed-steel buckets of semi-circular cross section. The inner surface of the casing is fitted with a series of gun metal reversing buckets arranged in groups, each group being supplied with a separate nozzle. The steam issuing from nozzle N at very high velocity, strikes one of the buckets on the wheel, and since the velocity of the buckets is comparatively low, is reversed in direction and directed into the first one of the reversing chambers. The chamber redirects the jet against the wheel, from which it is again deflected; this is repeated four or more times until the available energy has been absorbed by the rotor. Terry turbines are made in a number of sizes varying from 5 to 800 horsepower, and operate at speeds varying from 210 feet per second in the smaller machine to 260 feet per second in the larger.

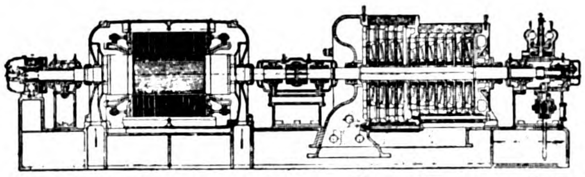


Fig. 2—Section through 1,000 kw. Kerr "Economy" Rateau type turbine-generator.

Kerr Turbine.

The Kerr turbine, Fig. 2, is of unusual design in that it is built up in sections, the casing comprising a steam end, exhaust end, and whatever number of intermediate stages are best suited to meet the individual condition. The rotor consists of a series of steel disks, mounted on a rigid steel shaft. A series of drop forged steel buckets is secured to the periphery and riveted in dovetailed slots. The tips of the buckets are riveted to a shroud ring, thereby insuring a rigid and positive spaced construction. The stator is made up of a number of arched cast iron diaphragms with circular rims tongued and grooved, and bolted to steam-end and exhaust-end castings.

The operation is as follows: Steam centers the turbine through a double-beat balanced poppet valve, the stem of which is connected through levers to the governor, to the circular cored space extending around the steam "enc casting." This space acts as an equalizer and insures uniform admission to the first set of nozzles. Partial expansion takes place through the first set of nozzles and the kinetic energy is imparted to the rotor through the medium of the vanes. Steam leaves the buckets at a very low velocity and is again expanded through the second set of nozzles in the diaphragm. This process is repeated in each stage.

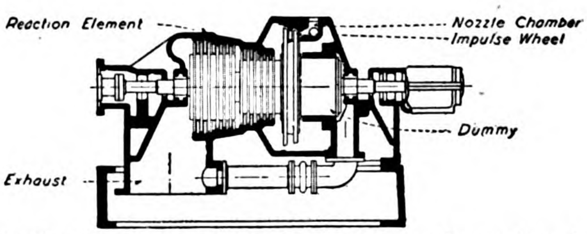


Fig. 3—Section of a combination impulse and reaction single-flow turbine.

Westinghouse Turbine.

In the Westinghouse impulse and reaction turbine, single-flow type, Fig. 3, the substitution of the impulse element for the high-pressure section of reaction blading has essentially no influence on the net efficiency of the turbine. That is to say the efficiency of the impulse wheel is about the same as the least efficient section of reaction blading. This design is attractive, however, in that under some conditions it shortens the machine and gives a stiffer design of rotor.

The entering steam is confined in the nozzle chamber until its pressure and temperature have been materially reduced by expanding through the nozzles. As the nozzle chamber is cast separately from the main cylinder, the temperature and pressure differences to which the cylinder is subjected are correspondingly lessened.

Westinghouse Double-Flow Turbine.

The maximum economical capacity of a single-flow turbine is limited by the rotative speed. The economical velocity at which the steam may pass through the blades of the turbine depends on the velocity of the moving blades. The capacity of the turbine depends on the weight of the steam passed per unit of time, which in turn depends on the mean velocity and the height of the blades. For a given rotative speed, the mean diameter of blade ring practicable is limited by the allowable stresses due to centrifugal force, and there is a practical limit for the height of the blades.

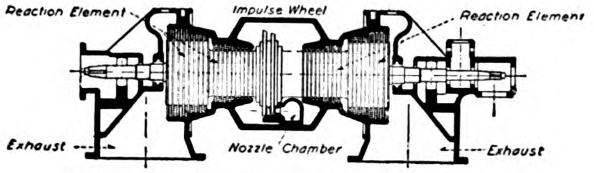


Fig. 4—Section of a double-flow turbine.

Now, if we make the rotative speed only half as great, the maximum diameter of the rotor may be doubled and, without increasing the height of the blades, the capacity of the turbine will be doubled. So with the single-flow steam turbine as well as with the single-crank reciprocating engine, there is a practical limiting economical capacity for any given speed. If this limit is reached with a single-crank reciprocating engine, we may produce a unit of double the power at the same speed by coupling two single-crank engines to one shaft.

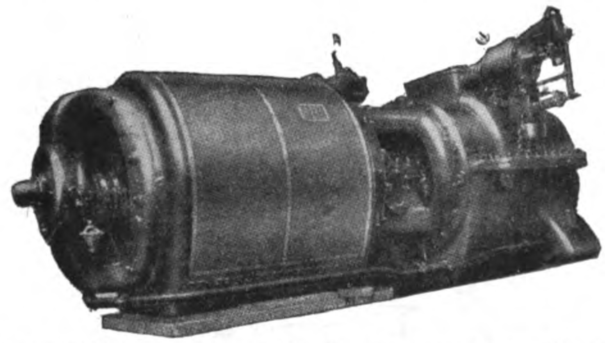


Fig. 5—1,000 kw., 60-cycle Curtis steam turbine with automatic extraction device.

The Westinghouse double-flow turbine is in effect, as will be seen from Fig. 4, two single-flow turbines made up in a single rotor in a single casing with a common inlet and two exhausts. Steam enters the nozzle chamber, acts on the impulse element, and then the current divides, one-half of the steam going through the reaction ding at the left of the impulse wheel; the remainder over the top of the impulse wheel and through the blading at the right..

urbine.

eneral Electric Curtis turbines, ranging from the very small direct current machines to the huge turbo-alternator of 40,000 kw, are of the impulse type. So many changes are made in these, as well as in other turbines from year to year, that descriptions can only be given in the most general terms.

In practically all sizes the high-pressure stage comprises a set of nozzles and a single wheel carrying two rows of buckets. Subsequent stages have but one row of buckets on a single wheel, except in the low-pressure element of the compound cylinder units where there are two wheels per stage, each with a single row of buckets. The steam flow is axial in all machines.

The speed in the smaller machines is controlled by a centrifugal governor, mounted on the end of the main shaft, which actuates a throttling valve of the balanced poppet valve type.

A relay governor of the hydraulic type controls the large turbo-alternators. Oil is fed to a cylinder under pressure through a pilot valve under control of the main governor. The piston rod of the cylinder contains a rack which meshes with the pinion on a camshaft, which in turn lifts the individual control valves, as determined by the spacing of the cams.

Bleeder Type Turbine.

One of the most interesting developments of the steam turbine is the so-called Bleeder, or Extraction type. Steam is automatically bled from an intermediate stage for heating or manufacturing purposes after it has passed through and done work in the high pressure stages of the turbine. Steam is usually bled at from one to 15 pounds pressure in quantities from a minimum amount up to the throttle capacity of the turbine.

It is probably due to the demands of the textile industry more than any other that this type of turbine was developed. The steam so bled is absolutely free from oil and may be used for dye vats, bleaching, slashing, etc., without danger of injury to the product.

In conclusion, it has only been possible here to describe in rather general terms the principles of operation and the details of construction by which the various turbines differ from each other. For a discussion of the advantages and disadvantages of steam turbines reference should be made to Part I of this article published last month. It seems well in closing to emphaize the fact once more that builders of turbines generally occupy a very high position in the engineering field, and that entire dependence can, as a general proposition, be placed upon the statements and recommendations of the various makers.

CLOSE BROKEN HILL PROPRIETARY PLANT

A cablegram to the Bureau of Foreign and Domestic Commerce from Trade Commissioner A. W. Ferrin at Melbourne, Australia, reports that the New Castle Steel Works of the Broken Hill Proprietary Company, Ltd., has been closed on account of the strikes at the mines of the company. The New Castle Steel Works employs about 5,000 men. During the year ending May 31, 1920, the company produced 296,000 tons of pig iron from two furnaces with a combined capacity of 1,000 tons daily.

Principles Underlying the Economical Firing of Boilers

Selection of the Proper Fuel and Type of Furnace It Should Be Burned in Are the Most Important Items—Boiler Regulation by Instruments Also Essential.

By CHARLES LONGENECKER.

THE degree of economy obtained in firing any boiler is best measured by the cost to evaporate 1,000 pounds of water in that particular boiler. This cost will include not only fuel but also labor, repairs, materials, etc. Too often stress is laid only on the amount of fuel burned, but this is by no means the sole consideration. In some instances where the furnace design is faulty the repairs to brick work may increase to alarming proportions, or when the coal is of a poor quality excessive "clinkering" may cause a high labor cost. At certain times in recent years the fuel market has been in a chaotic state and the supply interrupted so that in some plants it was impossible to obtain the class of fuel usually burned. In such cases the use of a substitute fuel for which the furnace was not adopted caused an increase in operating costs.

The item of greatest import will normally be the item covering fuel. This will vary from 25 to 75 per cent, depending on the type of plant. In large central stations with up-to-date appliances, this item will be low while in the small isolated plant it will be high.

The principles governing the economical burning of fuels are generally well appreciated, but this cannot be said in regard to their application. The failure to differentiate between the principle and its correct application is the one outstanding reason why there is so much mediocre furnace construction, and hence indifferent efficiency. It does not require experience to understand the principle, but it does require experience to apply it. The most important principle tending towards the economical firing of boilers—or furnaces of any description—is the maintenance of uniform conditions. Practically every invention covering an improved method of feeding coal, or any fuel, consciously or unconsciously, works to this end. Thus "hand-firing," except in rare cases, lacks all pretense of uniformity. Generally as we get away from dependence on the "human factor" we approach a more regular and uniform condition. The stoker has largely superseded hand-firing for the reason just stated. Oil, gas and powdered coal can be introduced into a furnace with the utmost exactness and hence maintain a steady temperature and an unvarying atmosphere. The various methods of boiler control all aim to maintain uniformity in the combustion chamber and for any particular variation in steam demand the air supply, damper opening and pressure in the chamber are uniform, for that particular variation. To detect any departure from the desired conditions, we have the draft guage, CO_2 recorder, etc. As regards brickwork it will stand up much longer where it is subjected to a constant temperature. It is varying temperature that causes the rapid deterioration, due to contraction and expansion. One of the most important requisites is the uniformity of air supply and distribution in relation to the coal. This, then, introduces the record principle which concerns the union of the oxygen of the air with the carbon and hydrogen of the coal.

It is generally stated that one pound of coal requires so many pounds of air to burn it. This is all well enough as far as it goes, but it does not go very far. In other words, it does not mean anything except from a theoretical standpoint. Any coal that is burned with the theoretical amount of air will, in practice, be very inefficiently consumed. The nearest approach to the theoretical will be when the coal is burned in powdered form, but here, too, there will be an excess amount of air. In burning this pound of coal the steps are more complex than many appreciate. The fixed carbon "must be burned and also the volatile combustible." One portion of the oxygen of the air unites with the "fixed carbon" a solid, while another portion combines with the carbon and hydrogen of the volatile. It may be interesting to see what these proportions are. The following is the "proximate" and "ultimate" analysis of a Pittsburgh vein bituminous coal:

Proximate		Ultimate	
Moisture	2.29	Carbon	79.53
Volatile	35.93	Hydrogen	5.08
Fixed carbon	55.87	Oxygen	6.51
		Nitrogen	1.62
Ash	5.91	Sulphur	1.21
		Ash	6.05

The total amount of air required to burn one pound of this coal, disregarding the sulphur, will be

Hydrogen	1.48
Carbon	9.61
	11.09

To burn the fixed carbon, 6.43 pounds of air will have to be furnished. The volatile combustible will require (11.09-6.43) 4.66 pounds of air. Expressed as a percentage, 42 per cent of the total air to burn coal must be supplied to the carbon and hydrogen existing in the volatile matter.

The steps in the combustion of the fixed carbon are generally recognized to be as follows: The carbon is oxidized to CO_2, which, coming in contact with hot carbon, is reduced to CO, according to the equation $CO_2\ C = 2\ CO$. The CO formed is again oxidized to CO_2. There exists some doubt concerning the exact order in which the carbon is oxidized, but the steps just given are accepted for want of any more conclusive evidence to the contrary. If there are thin spots in the fuel bed the carbon may pass away, as CO_2, and not be reduced to CO. Where the CO_2 is reduced and 2 CO is formed it is evident that we have to further oxidize the carbon. Thus, besides the volatile combustible originally in the coal, another gas, requiring further oxidization, is supplied by the burning of the "fixed carbon." Technical Paper No. 137, issued by the Bureau of Mines, gives, on page 63, the composition of the gases at the surface of a 6-inch fuel bed of a Murphy stoker. There are:

CO_2	6.2 per cent
O_2	3.4 per cent
CO	13.4 per cent
CH_4	1.0 per cent
H_2	9.0 per cent

In this instance 6.2 cu. ft. of every 100 is completely oxidized and will not be reduced. The 13.4 cu. ft. of CO must combine with an additional amount of oxygen.

The carbon in 6.2 cu. ft. of CO_2 is:

$$\frac{3}{11} \times 6.2 \times 1.98 = 3.348 \text{ oz.}$$

While the carbon in the CO is

$$\frac{3}{7} \times 13.4 \times 1.26 = 7.236 \text{ oz.}$$

The total carbon in these two gases is then 10.584 oz., of which 68 per cent is in the CO and must be further oxidized.

The point to be emphasized is that the largest portion of air furnished combines with the carbon existing in the gases and only a relatively small portion with the carbon existing as a solid. The total amount of hydrogen, except that portion in the form of water is, of course, in the gaseous form. The combustible gases arise from the fuel bed, according as the method of firing differs. A stoker fired furnace gives off its gases in a manner far different than a hand-fired, and in a powdered coal furnace the conditions are far different from either. Whatever the method of firing, it is evident that to secure the most thorough mixing of air and combustible gases the design of the combustion chamber is a controlling factor. The volume must be large enough to give the gases time to combine. The time factor in early installations was disregarded and today is not given the consideration it should have. In a design of furnace recently presented the distance between the grate bars and the first row of tubes was 26 inches. The results from such a design are evident.

Another factor of great importance is the maintenance of a temperature sufficiently high to assure quick ignition and complete the combustion before the tubes are reached. This is a question of the design of the setting and the draft. The velocity of the gases must not be too rapid, which again introduces the element of time. Some years ago the consumption of 25 pounds of coal per square foot of grate surface was a fair average, while today it is not uncommon to burn 40 or 50 pounds, and in many cases 65 pounds. Boilers of 150 to 200 per cent are very frequent. To obtain high ratings the volume of the combustion chamber is again a most vital factor if economy is to be secured. This is particularly true where high volatile coals are to be burned.

The design of the combustion chamber will be governed by a number of variables and each setting should be constructed according to the particular conditions under which the boiler will operate. In the early application of powdered coal to boilers, there arose many difficulties which were caused by improper furnace construction. The attempt was made to apply the coal to settings which had been built for either stoker or hand-fired furnaces and the results were in most cases disastrous. Trouble was experienced with the tubes, which were in many cases cooled with ash and furthermore the brickwork did not stand up. Later on the form and proportions of the setting were radically changed and operating conditions revolutionized. The idea of the day is to make the entire volume "effective" and eliminate eddies and pulsations. In the limited space available for this discussion, it is impossible to enter into details regarding design of combustion chambers, but two important features may be mentioned:

With a desire to economize in the installation of a boiler plant in a majority of cases the brickwork, etc., is reduced to a minimum. The result is a furnace too small for economic results. In other words, economical operation is sacrificed for a low first-cost and the loss in a year would pay many times over for a correct and adequate installation.

The use of first-class material in the setting is advisable and will pay dividends over the selection of an inferior grade. Thus with thick walls backed by a good insulating brick will prevent heat losses otherwise unavoidable. The radiation losses generally run about 5 per cent of the rated boiler output and any means spent to reduce this will aid in increasing output.

Probably one of the most instructive means for illustrating the pains that are taken in order to secure economy is a visit to one of the modern central stations. The majority of such stations have adopted some system of boiler regulation, previously alluded to. Such a system eleminates the "human factor" in controlling the combustion of the coal. Any one conversant with boiler firing recognizes the necessity of obtaining the correct pressure in the combustion chamber. This is hard to do where dependence must be placed on some employee. As the demand for steam varies the furnace conditions vary and there must be a means of simultaneously adjusting supply with demand. As the coal is increased or decreased the air supply is proportionately increased or decreased and the stack damper opened or closed, accordingly. With such changes the pressure in the furnace is maintained constant at approximately what is termed "balanced draft." If the pressure in the combustion chamber is too great there will be destruction of the brick work, while if the pressure is below atmospheric cold air will be drawn in. The means for effecting these adjustments are all synchronized and are controlled by the demand for steam.

A great many boilers, in plants of large size, are now equipped with super-heaters and all boilers should be. It is estimated that the following saving can be made by super-heating the steam 150 degrees:

In simple engines	20 to 25 per cent
Compound engines	15 to 20 per cent
Triple expansion engines	14 to per cent
Unaflow expansion engines	about 10 per cent

With such savings possible it is hard to understand why only 15 per cent of all the steam generated is super-heated.

There is no factor of greater importance than the "Herman Factor," as on it depends, according to David Moffa Myers, "one-fourth of the factory's

(Continued on page 238)

Grateless, Smokeless, Automatic Furnace for Steam Power Production at the Mines

Radical Revolution in Power Generation by the New Method of Burning Coal, Not Only Promises Higher Efficiencies and Greater Economies, but Is Expected to Solve the Smoke Problem.

THE announcement by the Stephens Engineering Company of the development of a new process of combustion is attracting considerable attention since it has become known that the Stephens Process has been worked out in application for use in land boilers to a state of perfection that warrants putting it on the market for commercial use in the generation of steam.

The accompanying is an illustration of the operation and a brief description of the new invention, which is known as the Stephens Process of Combustion, and which is protected by United States and foreign patent rights.

Statement, by W. G. Howard, sales manager, Stephens Engineering Company:

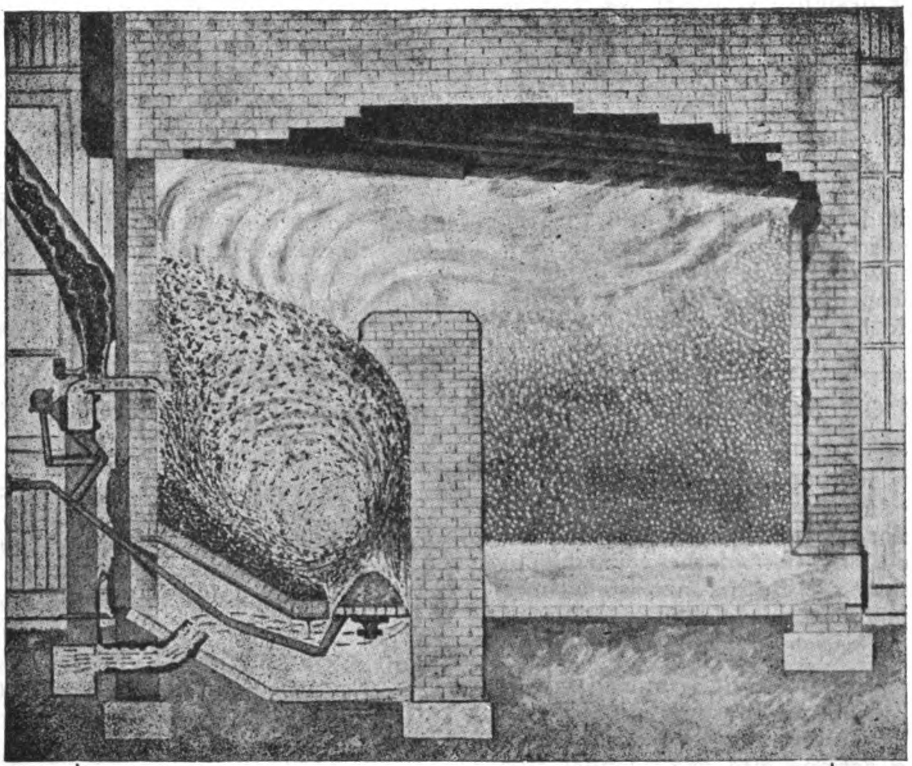
One of the most fertile fields of the expert is that relating to the economical use of coal. Never in history has the importance of conserving fuels been so sharply emphasized as at present. In view of the vast importance that suddenly became attached to conserving coal as an event of war, it should now rank ahead of every other branch of engineering, concerned with the production of light, heat and power.

Insofar as boilers are concerned the Stephens Engineering Company has developed a process that will help to relieve the situation. Briefly stated this process is a new principle based upon the discovery that it can carry coal into suspension with less air than is required to burn it. This permits setting up a vortex as above described in which all the volatiles and coke are completely and efficiently consumed before they reach the boiler tubes, and thus most certainly beyond the tubes—the stack. There is also an arrangement that saves the developed heat in the ash before they are dumped into the ash pit.

Fuel conservation depends upon the education of all those who have to do with fuels—producers, transporters, and those engaged in the final employment of fuels for useful purposes.

As a base to start from there is one general rule that applies to all furnaces for boilers; namely, that furnace is the best furnace which completely and efficienty consumes all of the combustibles with the least surplus of air.

The Stephens Engineering Company in engaging to fulfill the theoretical and practical requirements for a satisfactory, efficient and economical firing system for boilers, has constructed a stoker of the utmost simplicity of design to the end of, first, burning perfectly all of the coal completely and efficiently, and, second, getting the maximum of heat out of each pound of coal in the furnace area, and, at the same time, radiating and conveying that heat intact to the exact point where the heat is desired.



Showing the process in operation under a standard water tube boiler of 200 hp, at the Stephens Laboratory, United States Bureau of Mines, Pittsburgh, Pa.

The downward sweep of air coming through the front of the furnace carries measured quantities of fuel consisting of dust, fine particles up to pieces three-quarters of an inch in size. The dust and fine particles burn in suspension. The larger particles cast upon the inclined bed, when incandescent, flow toward the bridge wall, where the bed is disrupted by an oscilliating platform, and an upward sweep of air carries the disrupted constituents of the flowing mass along the bridge wall to the overhanging arc, which deflects them back to the front wall of the firing chamber, and, dropping, they re-enter the downward sweep of air and fuel and in this manner constitue an active vortex, in which not only all coal, but also all of the smoke is completely burned, and the vortex at all times operates uniformly even though the boiler is suppressed or forced in order to lower or raise the steam generation.

We have thus achieved scientific combustion as follows: without grates — without arches — without smoke.

Our boiler furnace is:

1. Automatically self-feeding.
2. Easily regulated to maintain any temperature desired.
3. Completely burns every particle of combustible and also saves the heat in the ash.
4. Keeps clean the entire furnace atmosphere by absolute smokelessness, saving waste, annoyance and damage.
5. Completely and efficiently burns cheap grades of slack coal as economically as high grade coal without any structural change in the furnace or its equipment, and without any extra attention whatever.
6. Can at any time be speeded up or down with complete efficient smokeless burning of the fuel in either case.
7. Forcing to meet sudden demands is practically instantaneous.
8. There are no clinkers.
9. The ash can be disposed of automatically after first fulfilling condition number three.

The company's laboratory is equipped with a standard water tube boiler and all facilities for making tests to demonstrate the above claims and also to show the efficiency of the process in burning lignites, coke braize, anthracite culm and the like, all in the same furnace.

PRINCIPLES UNDERLYING THE ECONOMICAL FIRING OF BOILERS.

(Continued from page 236)

yearly coal bill." In his book, entitled "Factory Power Plants," Mr. Meyers states "The firemen in our boiler plant will, in the future, be far better paid, their working hours will not be excessive, and the boiler rooms will be better ventilated. The firemen will be given a direct financial interest in eliminating the preventable waste of fuel; they will receive specialized education to enable them to produce very large economies that only await such educational incentive. They will become skilled workers who will annually save for their companies 10 and 20 times the increase in their wages."

Any discussion of the utilization of fuels is not complete unless it embodies a discussion of the furnaces in which the particular fuel or fuels are burned. The fuel is, so to speak, merely the container in which the heat is carried. Its utilization is altogether a function of the furnace, which may be of correct or incorrect design. Whether the fuel is a gas, a liquid or a solid is no criterion of the satisfaction it will give. It is merely a question of adaptability. The chemical composition of the fuel is an index to the potential heat contained therein per unit, but it does not indicate what results may be secured in the combustion chamber. Likewise the calorimeter tells how many Btu. are contained in a unit quantity of fuel, but it does not tell the cost to heat a unit quantity of material with the particular fuel. Experience points the way and is the only guide in the selection of the proper fuel and the type of furnace in which it should be burned.

THE LOGIC OF ROLL DESIGN.

(Continued from page 211)

Practically the only work done on the closed part of the groove is to reduce the height of the flanges to take care of the elongation of the sides of beam to compensate for the elongation of the web, due to its reduction in thickness. Beams are sometimes rolled diagonally to increase this slabbing action of the tongue roll.

The most difficult section to roll is one in which thin flanges must be produced in some part of the section, on which it is impossible to bring any of these various slabbing actions into use. Under this condition these flanges must be worked up gradually, requiring a much thicker billet to start with in order to get flanges to height.

Other sections which apparently could not be rolled in their finished shape are rolled, opened out into a shape that will deliver from the rolls and then bent up into their final shape in a bending pass; a good illustration of this type of section is sheet piling.

In designing all sections, the roll designer must use good judgment in proportioning the reduction of section in order that the bar may deliver straight and not be robbed in spots by wire drawing effects.

The object of these articles was to demonstrate the Principles governing design, rather than any particular Form of design. As the form will depend upon the conditions existing in each individual mill.

ENGINEERS DISCUSS STEEL TOPICS.

IRON and steel topics played an important part in the winter meeting of the American Institute of Mining and Metallurgical Engineers, February 14-17, at the Engineering Societies building, New York. Two sessions on Tuesday were devoted entirely to the discussion of subjects touching upon the metallurgy and manufacture of iron and steel, while on Wednesday two sessions were devoted to the presentation of detailed information on the breakage and heat treatment of drill steel. The discussion on this subject led to a number of important phases of the manufacture of drill steel and resulted ultimately in a resolution to the effect that the American Institute of Mining and Metallurgical Engineers establish a board in co-operation with other engineering societies and government agencies to investigate the breakage and heat treatment of rock drill steel and other steels subjected to similar stresses. This resolution was unanimously adopted and will go to the board of directors of the institute for action.

Another subject which received attention during the meeting was that of industrial relations, one entire session and parts of others being devoted to employment and welfare problems. Other topics discussed during the meeting dealt with nonferrous metallurgy, nonmetallic minerals, mining and milling, coal mining and petroleum ad gas.

The annual banquet was held at the Waldorf-Astoria Hotel last Wednesday evening. W. L. Saunders, Ingersoll-Rand Company, New York, presided as toastmaster. Herbert Hoover, retiring president of the institute, delivered a brief address devoted almost entirely to a review of the activities of the organization during the past year. Edwin Ludlow, New York, incoming president, emphasized the importance of the labor problem.

CONVENTION CALENDAR.

April 20-21—National Metal Trades Association. Annual convention, Astor Hotel, New York. Homer D. Sayre, Peoples Gas Building, Chicago, is secretary.

April 21-23—American Electrochemical Society. Spring meeting at the Hotel Chalfonte, Atlantic City, N. J., Joseph W. Richards, Lehigh University, Lehigh, Pa., is secretary.

May 5-6—British Iron and Steel Institute. Spring meeting at the Institution of Civil Engineers, Great George stret, London, S. W. 1. The secretary is George C. Lloyd, 28 Victoria street, London, S. W. 1.

May 9-10-11—American Association of Engineers.

Annual convention ot be held in Buffalo. National association headquarters, 63 East Adams street, Chicago.

BOILER HOUSE MANUEL.

A reference manual to aid the owner, manager and operator in securing and maintaining boiler plant economy entitled "Finding and Stopping Waste in Modern Boiler Rooms," has been published by the H. S. B. W. Cochrane Corporation to be sold at $1.00. It is one of the most interesting books published on this subject.

FOREIGN RELATIONS

NEW ARMOR PLATE FOR GOVERNMENT STEEL FOUNDRY IN CHINA.

The Yawata Steel Works, the Government foundry, is to have a special department for the production of the extra thick steel plates required in the construction of the new war ships designed to constitute the first line in the future navy, states the Far Eastern Review. It is stated, however, that it will be about two years before the prescribed output of 90,000 tons per annum will be attained because of the inexperience of the workmen.

TOKYO MUNICIPALITY PLANS NEW BRIDGES

According to the Japan "Advertiser," a scheme at an estimated cost of 1,400,000 yen is planned by the municipality of Tokyo for the construction of 1,000 bridges. Three hundred of the bridges now of wood are to be replaced by iron-framed structures.

AMERICAN BOILERS FOR BRITISH COLONIES.

American manufacturers of boilers for marine and stationary engines should bear in mind that boilers intended for British Malaya must meet the specifications required by the British Board of Trade. It is emphasized by Consul General Dickson that though the American specifications may differ from the British merely in the matter of the thickness of the head, such variations should be adjusted by American manufacturers. A number of power plants have recently been installed in this district, and as it is reasonably certain that the market for boilers is on the increase it is of vital importance that the American product should conform to British requirements.

DEMAND FOR TIN PLATE.

While the demand for tin plate in Japan is annually increasing, according to "Finance and Commerce," owing to the development of the petroleum and canned food industries, the manufacture of tin plate is difficult to carry on, the producers being unskilled and the cost of production high. During the four years 1911-1915 the annual importation of tin plate averaged about 26,000 tons, valued at approximately 4,000,000 yen. The following figures indicate the increase in quantity and value which has taken place since then:

	Tons	Yen
1916	39,305	10,083,697
1917	26,848	11,725,622
1918	29,311	20,836,713
1919	37,336	17,515,565

INDUSTRIAL DEVELOPMENT IN CHINA.

In spite of many hindrances, industrial progress in China continues. The Ministry of Agriculture and Commerce recently compiled statistics showing the number of new companies registered in Peking, as follows:

Industry	No. of companies	Total Capital
Cotton mills	16	$ 6,673,600
Mining companies	12	9,472,785
Electric	26	3,123,785
Transportation	18	6,866,000
Commercial	15	13,373,000
Agricultural	16	8,629,000
Manufacturing	53	21,721,300
Fishery	3	1,055,000
Miscellaneous	8	2,463,000

The largest number of these enterprises are located in Chihli, while those in Kiangsu Province rank next in number.

RICH TUNGSTEN ORE IN ARGENTINA.

Trade Commissioner George S. Brady has forwarded a sample of tungsten ore from the Province of Catamarca, Argentina. The Bureau of Mines has made analysis of this ore which shows that it contains 64.46 per cent wolfram, 10.95 per cent silica plus insoluble matter, and considerable calcium carbonate. In other words, the material is about 80 per cent scheelite, 11 per cent silica, etc., and 9 per cent soluble matter, mostly calcite. The name of the owner is not given by Mr. Brady, but if any American companies are interested in Latin American Division of the Bureau of Foreign and Domestic Commerce can obtain a report upon the matter.

NEWCASTLE STEEL WORKS.

An expenditure of about £3,500,000 has been decided upon by the directors of the Broken Hill Propriety Company (Ltd.) for extensive additions to the present plant at the Newcastle Steel Works, where already 5,000 men are employed. The demands of the Commonwealth for adequate supplies of iron and steel for newly established industries as well as increased orders from abroad brought about this decision. Two representatives of this company have been sent to the United States for the purpose of gleaning information relative to the cost of the required additional machinery, according to advices from Consul General Sammons, of Melbourne. All additions are planned to be completed in two years. Another blast furnace, making four in all, is to be erected, together with the added number of coke ovens required. A by-product plant will be used in connection with the coke ovens. Other additions include a duplex steel plant, a continuous mill for the rolling of steel bars and billets, a duplication of the present rod mill, and a sulphuric-acid plant for the supply of acid in connection with the production of sulphate of ammonia and for galvanizing.

FRENCH STEEL AND PIG-IRON PRODUCTION FOR FIRST NINE MONTHS OF 1920.

(Consul E. L. Ives, Paris, Nov. 3, 1920.)

The production of pig iron during the first nine months of 1920 has shown a steady increase, from 195,116 metric tons (metric ton=2,204 pounds) in January to 347,451 metric tons in September, with the exception of the month of April, the production of which amounted to 179,464 metric tons. (For other reports on this industry see Commerce Reports for May 14 and July 8.)

The monthly production of pig iron in metric tons, as estimated by the Comité des Forges de France (provisional figures), is as follows: January, 195,116; February, 205,227; March, 198,445; April, 179,464; May, 223,510; June, 270,756; July, 299,980; August, 321,293; September, 347,451.

Steel Production During the First Nine Months of 1920.

The tonnage production of raw steel (ingots and castings) during September, 1920, shows an increase over the amount produced in January of 104,471 metric tons.

NEWS OF THE PLANTS

The Lebanon Valley Iron & Steel Company, Duncannon, Pa., is making a number of extensions and improvements at its plant for increased production and operating efficiency. The work will be completed at an early date, and the finishing mill placed in service. This partial operation will be followed by the entire plant shortly thereafter.

The Ashtabula Steel Company, Ashtabula, O., has construction under way on a new sheet mill plant, and proposes to have the works ready for service early in the summer. The new plant will consist of eight sheet mills, eight combination furnaces using powdered coal as fuel, two continuous annealing furnaces and two galvanizing pots. The power installation will consist of a duplex engine, 28x36 inches, operating at 150 rpm, with gear reduction of 5 to 1.

The Tennent Steel Casting Company, Tacoma, Wash., has perfected plans for the establishment of a new branch plant at Centralia, Wash., where a large part of production will be given over to the manufacture of castings for automobile and other service. The company will remove a portion of its present works to the new location, with such extensions in equipment and facilities as may be required. The initial plant will give employment to about 50 operatives, and this number, it is said, will be increased at an early date.

The United Engineering & Foundry Company, Farmers Bank Building, Pittsburgh, Pa., will take bids in the spring for the construction of a new plant building at Fifty-fourth street and the Allegheny Valley Railroad. The structure will be one-story, 50x150 feet, and is estimated to cost about $50,000. The company operates branch plants at Youngstown and Canton, O.

The Robesonia Iron Company, Lebanon, Pa., is arranging for a number of improvements and repairs at its local blast furnace. The unit was recently blown out, and during the idle period it will be relined and improved. A new hoist and other machinery will be installed at the plant. It is expected to start the work in the summer.

The Judson Manufacturing Company, San Francisco, Cal., expects to continue the improvement program at its plant during the present year, as in 1920. A new automatic stripper tower will be installed in the open-hearth department and other installations made for increased facilities. A new 30-ton open-hearth furnace was placed in service last year, making a total of three furnaces at the plant, with aggregate capacity of about 6,000 tons of material a month. The rolling fill department, improved and extended at the same time, now comprises a 16-inch bar mill, 19-inch bolt mill and two 10-inch mills.

The Sterling Steel Foundry Company, Braddock, Pa., has preliminary plans under way for the rebuilding of the portion of its plant destroyed by fire on January 27 with loss estimated at about $75,000. The plant has been giving employment to about 300 operatives.

The New England Iron Works, Dixwell aevnue, New Haven, Conn., has preliminary plans under way for the installation of new equipment at its plant for increased production. Extensions will be made to house the new machinery, which will consist of an electric traveling crane, steam hammer, shearing machinery and other equipment. The company specialize in iron and steel fabricating work.

The Peden Iron & Steel Company, Fort Worth, Tex., is planning for extensions and improvements in its plant at Main and Daggott streets, to form a complete new operating unit. The new building will consist of rolling mill, fabricating plant, metal and iron-working departments, machine shop, power house and other structures. Details of buildings and machinery installation are now being arranged. The project is estimated to cost about $1,000,000. D. B. Luce, Fort Worth, is engineer for the company.

The Hanna Furnace Company, Dover, O., will make extensive improvements at its blast furnace. It is planned to reline the furnace and build three new 22x100-foot stoves. Considerable new equipment will be installed in the power house, including five 2,000 horse power boilers, electric turbine and auxiliary operating apparatus. A new pumping plant will be constructed and a new warehouse.

The Indiana Rolling Mill Company, New Castle, Ind., is making a number of extensions at its plant for increased production. A new sheet mill is being completed, comprising a 28-inch mill and other equipment to provide a capacity of about 120 tons in 24 hours. An extension to the main building has been completed, and power house constructed, this latter building replacing a structure destroyed by fire early last year.

The National Tank & Steel Company, East St. Louis, Ill., is considering the erection of a new one-story addition to its plant for increased production. Details of the structure and proposed equipment are being arranged. It is estimated to cost about $50,000.

The New England Iron & Metal Company, Manchester, N. H., has plans under way for the erection of a new local plant for the manufacture of iron and steel products. The proposed structure will be 25x152 feet, and is estimated to cost about $60,000.

The Tennessee Coal, Iron & Railroad Company, Birmingham, Ala., has plans under way for the erection of an addition to its plant at Westfield, near Birmingham, for the purpose of increasing present output. The structure will be used for the manufacture of steel products and is estimated to cost $300,000, including machinery.

L. P. Featherstone, Longview, Tex., and associates have organized a new company, to be known as the Texas-Louisiana Steel Corporation, with capital of $10,000,000. The new organization will take over the holdings of the Texas Steel Company and the Louisiana Steel Company. Property has been acquired about 40 miles north of Longview as a site for the erection of a new steel plant. A blast furnace of about 4505 tons capacity will be constructed, as well as a series of mill buildings for steel and iron production. Details of the project are being arranged, and it is proposed to inaugurate operations at an early date.

WITH THE EQUIPMENT MANUFACTURERS

NEW AUTO-TRANSFORMER STARTER MADE BY CUTLER-HAMMER

Central stations almost universally require that standard squirrel cage induction motors of 5 hp rating or over be provided with starting devices in order to avoid the line disturbances resulting when the motor is started by connecting directly to the supply system. For various reasons the auto-transformer starter or compensator is generally considered to be the most satisfactory device for this service. The squirrel cage motor, because of its inherently simple construction, will withstand unusually severe service with only an occasional overhauling. This cannot be said of starting devices as a class and, therefore, where squirrel cage motors are used the weakest link in the power system is generally the starter or controller. The value of a dependable starter is generally realized in those industrial plants where a shut-down, even if for only a half hour, is costly in terms of wages and finished material.

The Engineering Department of the Cutler-Hammer Manufacturing Company of Milwaukee, has devised an auto-transformer starter of unusually rigid construction to meet the severe requirements of the large industrial plant and mine, as well as that of the small mill and factory. The simple steel construction—using no wood or castings whatsoever—the absence of flexible moving leads, and the ease of inspection of the contacts and adjustments of the relays, enable this starter to give continuous and satisfactory service at a low upkeep cost. This starter is shown in the accompanying illustrations, and consists of two auto-transformers, commutating mechanism, low-voltage release and duplex overload relay, all enclosed in a sheet metal case with the operating lever outside. The case is strongly reinforced with angle iron, and has a hinged cover which can be lifted to expose the transformers and relay. The transformers and case are carried directly on the supporting brackets and may be readily mounted on the wall, switchboard, or any post or pedestal.

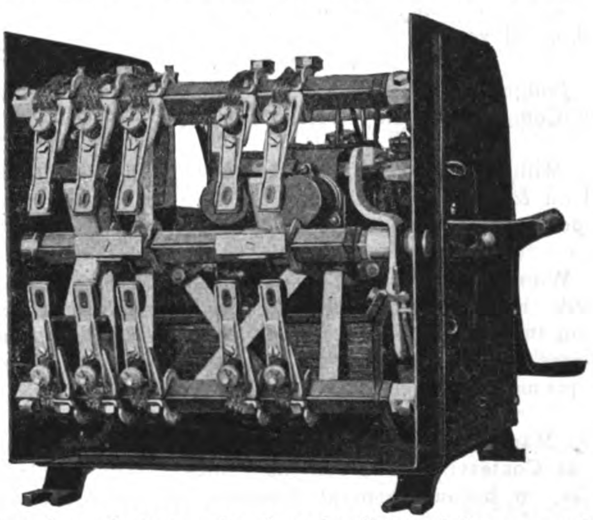
The starter is operated by moving the operating lever forward to the starting position and then backward to the running position, where it is held in place by the low-voltage mechanism. Interlocks prevent moving the lever directly to the running position. If released in the first or starting position, the lever is returned to neutral by a spring. It may be locked in the neutral position to prevent unauthorized operation.

The auto-transformers connected in open delta are used for both two and three phase service. The special construction of the transformer core allows either coil to be easily and quickly replaced. Each coil is provided with three accessible taps which give 50, 65 and 80 per cent of full line voltage.

The oil-immersed commutating mechanism is placed at the bottom of the case below the transformers and may be exposed for inspection by the removal of the oil pan, which is made a simple one-man job by means of the combined handle and holding clamp used. An ample head of oil is maintained above the contacts and a double horizontal break is provided in each line. Breaking the circuit horizontally confines the arc between the copper contacts and prevents burning of parts not designed for that service. The sliding action of the contacts keeps them clean and breaks any film of oil which might form between them and produce destructive arcing. The contacts are carried on steel supports clamped on insulated square steel bars. No wood or other flammable material is used in the construction. The stationary contacts are drop forged pieces of copper carried on fingers of standard C-H construction. These fingers are of the non-stubbing type, and are easily adjusted and renewed. The moving contracts or segments are short copper strips, reversible so as to give double the normal amount of service.

The low-voltage mechanism is mounted inside the case on the right hand side. A wire from the armature of the release coil extends through the case near the operating handle and is bent to form a hook, a slight pull on which releases the starter and returns the handle to neutral. Remote control of stopping may be obtained by inserting one or more normally closed push button switches in the low-voltage coil circuit. Pressing any one of the buttons releases the starter mechanism.

A duplex overload relay with a true inverse time limit movement is mounted inside the case on the transformer assembly in such a position that adjustments for time and current values can be readily made. This duplex relay is equivalent to two overload relays, each in series with one of two phases. The Underwriters' rules do not require installing a disconnecting knife switch or circuit breaker ahead of this starter when thus equipped, because the starter completely disconnects the motor from the supply line when released by an overload.


Under view of starter showing simplicity of finger construction and arrangement. The fingers are non-stubbing and are readily adjusted for wear.

Rigid copper leads are used throughout, with the exception of four flexible stationary leads to the transformer taps and low-voltage coil. The flexible leads are out of the way of the moving parts; therefore all danger of leads becoming broken or grounded by bending or rubbing is eliminated.

These starters are made in various sizes for the operation of two or three phase induction motors rated between 5 and 100 hp on standard commercial voltages between 110 and 2,200 and at frequencies of 60, 50, 40, 33 and 25 cycles per second.

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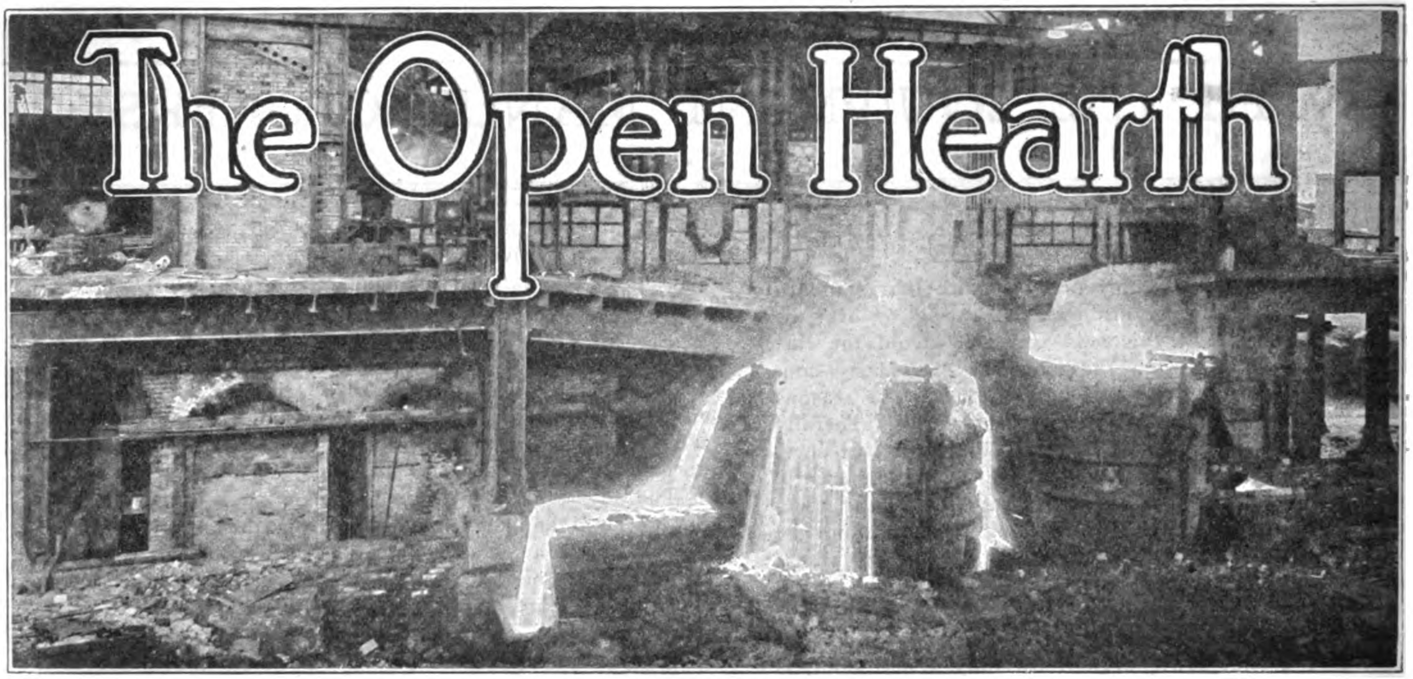
The Open Hearth



Samuel A. Benner, formerly vice president of the Federal Steel Export Company, New York, and previously general manager of sales of the American Steel Export Company, New York, is to become president of the Empire Tube & Steel Co., College Point, L. I., it is announced. Mr. Benner's experience in the iron and steel industry embraces a period of 33 years.

V V

J. C. Jenkins has been elected president of the Belding Foundry Company, Belding, Mich.

V V

F. C. Milliken, who has been connected with the Alan Wood Iron & Steel Co., Philadelphia, for many years, has been appointed assistant to the president, W. W. Lukens.

V V

F. P. Wood, vice president of the Burlington Steel Company, Ltd., Hamilton, Canada, has been elected president, succeeding the late Sir Frank Baillie. W. D. Ross has been elected vice president to fill the vacancy caused by Mr. Wood's promotion.

V V

R. M. Marshall has resigned as blast furnace superintendent at Coatesville, Pa., for the Midvale Steel & Ordnance Co., to become general manager of the American Manganese Mfg. Co., in charge of the latter's operations at Dunbar, Pa., effective February 1. M. J. Scammel resigned recently as general superintendent of company's plant at Dunbar.

V V

L. A. Lenhart, recently made vice president of the Youngstown Steel Car Company, Niles, Ohio, has resigned as plant manager of the General American Tank Car Corporation, East Chicago, Ind.

V V

Louis A. Way, who has been made assistant to the president of the Duquesne Steel Foundry Company, Pittsburgh, in charge of sales, had been with the company 16 years prior to going with the Lewis Foundry & Machine Co., Pittsburgh, from which he resigned as works manager February 1.

V V

I. P. Blanton, assistant to the president of the Kelly Nail & Iron Co., Ironton, Ohio, has been made general manager of the company. He relieves the president, Oscar Richey, who was also general manager, of the active management of the company. Mr. Richey's health has required a lessened strain of duties.

V V

J. H. McElhinney, engineer in charge during construction of the new tandem rolling mill of the Columbia Steel Company, Elyria, Ohio, has been made assistant manager of the company. Formerly he was assistant engineer of the Youngstown Sheet & Tube Co., Youngstown, Ohio.

V V

Frank L. Klingensmith, vice president and treasurer of the Ford Motor Company, Detroit, and for 15 years associated with the company, has resigned, declaring he is not in accord with some of the contemplated future business policies of the company. Charles A. Brownell, advertising manager of the Ford Company, also has resigned, and it is reported W. F. Knudson, production manager, and B. F. Craig, secretary, have tendered their resignations. Charles E. Sorenson, head of the tractor plant and blast furnaces, will succeed Mr. Klingensmith as vice president, it is reported.

V V

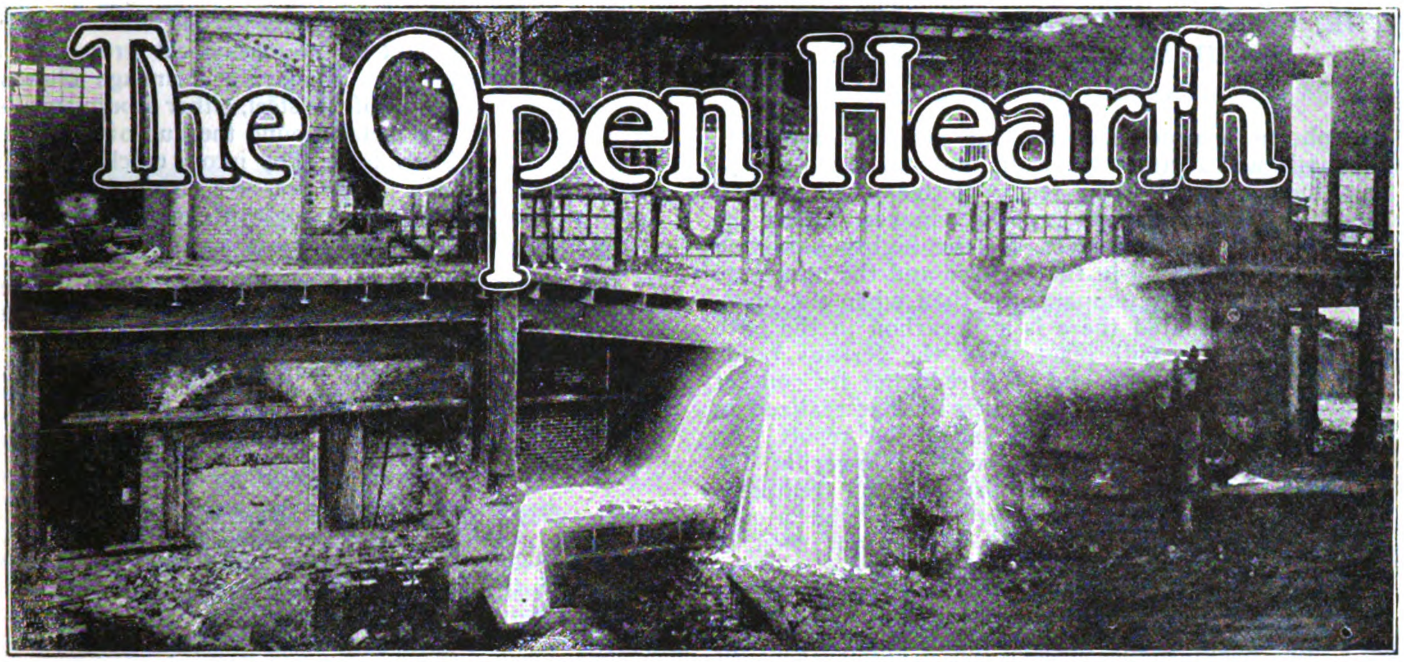
H. Donald Dickinson, formerly superintendent West Penn Forge Company, Pittsburgh, has been appointed assistant to E. B. Rouse, superintendent Chester Works, American Locomotive Company.

V V

Charles K. Nichols, for the past 10 years general superintendent of the West Penn Steel Company, Brackenridge, Pa., has been named vice president and general manager of the company, to succeed John McGinley, who died January 29. Mr. Nichols has been active in the steel industry in an operative way since early manhood, having worked up through the ranks. At one time he was a roller at the Vandergrift, Pa., works of the American Sheet & Tin Plate Co., and when the late Mr. McGinkey became general superintendent of the Allegheny Steel Company, Brackenridge, Pa., Mr. Nichols served under him in the capacity of sheet mill superintendent. He subsequently went along with Mr. McGinley when the latter, with others, organized the West Penn Steel Company.

V V

Alexander England has been named chief engineer of the Westinghouse Air Brake Company, Wilmerding, Pa., to



succeed S. W. Dudley, who resigned February 1, to join the faculty of the Yale University as professor of mechanical engineering. Mr. England has been affiliated with the Westinghouse Air Brake Company for 22 years and had held the position of assistant chief engineer since 1914. He was born in Dundee, Scotland, and served an apprenticeship in marine engineering with the Scotch shipbuilding firm of Pierce Bros. He subsequently earned a diploma in mechanical engineering from the City and Guilds of London Technical Institute. Coming to the United States in 1887, he became identified as assistant superintendent with the Thomas Carlin's Sons, Pittsburgh, hoisting engines and machinery, and later became superintendent of the Specialty Mfg. Co., Pittsburgh, machine builder. He assisted in the reconstruction of the Eliza furnace plant, Jones & Laughlin Steel Co., as engineer in charge of designs for equipment in handling coal and coke. Several changes as the result of Mr. Dudley's resignation and Mr. England's promotion have been announced. R. E. Miller, engineer of tests and inspection, has been promoted to superintendent of tests and inspection; W. E. Dean, assistant engineer of tests, has been made engineer of tests; A. A. Mackert, chief inspector, has been made engineer of inspection.

√ √

W. H. Baker has been elected a dircetor of the Electric Alloy Steel Company, Youngstown, Ohio. He is also secretary, treasurer and general manager of the Universal Steel Company, Bridgeville, Pa.

√ √

Thomas S. Hutton, for several years connected with the Southern California Iron & Steel Co., Los Angeles, Cal., has been made Pacific Coast manager for the Ludlum Steel Company, Watervliet, with offices in the Rialto Building, San Francisco.

√ √

Henry Wick of Cleveland has been elected a director of the Elyria Iron & Steel Co., Cleveland, succeeding Frank R. Guyon, who resigned from the company.

√ √

Robert M. Kilgore, who for the past two years has been assistant manager of sales at Pittsburgh for the Jones & Laughlin Steel Co., has been transferred to the company's New York territory. He succeeds H. F. Halloway, who retires on account of his health. Mr. Halloway has been affiliated with the Jones & Laughlin Steel Co. since about 1898.

√ √

R. A. Kenworthy, Jr., has been elected secretary-treasurer of the Newton Steel Company, Newton Falls, Ohio. J. L. Harrison has succeeded Mr. Kenworthy as general manager of sales, with offices in the Wick Building, Youngstown, Ohio. G. H. McVey, formerly associated with the sales organization of the Allegheny Steel Company, now is with the Newton Steel Company in the same capacity.

√ √

G. Gordon Green, formerly blast furnace construction engineer Tata Iron & Steel Co., Ltd., India, sailed from Seattle, January 27, to assume similar duties with the Lungyen Mining Administration of China, which is erecting near Peking a 250-ton blast furnace of Pekin & Marshall's design.

√ √

A. W. A. Eden, formerly assistant structural engineer with Westinghouse, Church, Kerr & Co., Inc., has become affiliated with the Harris Structural Steel Company, New York.

√ √

George F. Wright, formerly vice president Wickwire-Spencer Steel Corporation, Worcester, Mass., and for the past year secretary of its operating committee, has resigned. He plans to take a vacation and then enter business for himself in Worcester.

√ √

Lewis Taylor, assistant chief engineer McClintic-Marshall Company, Pittsburgh, has been appointed chief engineer of the company, succeeding the late Paul L. Woelfel. Mr. Taylor has been identified with McClintic-Marshall Company since shortly after its organization and has held a position as assitant chief engineer for the past 12 years. His experience includes an important part in the construction of most of the large bridges and other structures erected by the company. He graduated from the University of Pennsylvania in 1900 and is a member of the American Society of Civil Engineers' Society of Western Pennsylvania, and the American Society for Testing Materials.

TRADE NOTES

The Combustion Engineering Corporation announces the opening of a branch office in Atlanta, Ga. This office has been placed in charge of A. A. Hutchinson, who has had an extensive experience in the engineering field and is widely known in the South, having been actively engaged in the field of combustion generally for the past 14 years and during that period been in charge of important development work.

The Ohio Electric & Controller Company, Cleveland, O., wish to announce that they have appointed Arthur H. Abbott, 88 Broad street, Boston, Mass., as their New England representative for the sale of Ohio Mill Type Lifting Magnets and Ohio Ball Bearing fractional sized motors.

The Charles Austin Hirschberg, Inc., handling Keller Mechanical Engraving Company, advise that their address is 150 Nassau street, New York City, instead of 120 Liberty street, New York City.

Arthur G. McKee & Co., 2422 Euclid avenue, Cleveland, O., have been awarded a contract by the Emporium Iron Company, Emporium, Pa., covering the precision of a new hearth jacket and cooling plates, for their furnace, new hot blast stove fittings, etc.

N. B. Payne & Co., 25 Church street, New York, dealers in electric cranes and hoists, have extended their lines of material handling machinery to include the portable conveyors of the A. C. Warner Company, Philadelphia, Chicago automatic coal elevators and McKinney-Harrington package pilers and car loaders.

Edmund Otto, for several years secretary of the Hardware and Supply Company, and prior to that associated with Manning, Maxwell & Moore, Inc., New York, is now associated with N. B. Payne & Co., in this branch of their business.

E. D. Kellogg has recently been appointed New Jersey representative for the Conveyors Corporation of America, formerly American Steam Conveyor Corporation, manufacturers of machinery for handling coal, sand, gravel, ashes and other loose, bulky materials. He will handle "The American Trolley Carrier" and "The American Steam Jet Conveyor" in the northern half of the State, but will make his headquarters at their Eastern office, 110 West Fortieth street, New York.

L. W. Rench has been appointed secretary and general manager of the International Oxygen Company, succeeding Eugene Schoen, resigned.

The Conveyors Corporation of America, formerly the American Steam Conveyor Corporation, Chicago and New York, announce that S. D. Inman has been placed in charge of the engineering and design of their American Trolley Carrier, monorail conveying equipment for handling coal, ashes, sand, gravel, and like bulky materials from railway car to pile, bin or bunker.

Frank Hodson, president of the Electric Furnace Construction Company, Philadelphia, has been elected member of the executive committee of the Philadelphia Foundrymen's Association.

F. J. Ryan & Co., Franklin Trust Building, Philadelphia, specialists in electric heating problems in both the chemical and metallurgical industry, announce the electon of the followng departmental executves: S. H. Ourbacker, drector of engineering; F. A. Hall, director of sales; T. B. Bechtel, director of construction.

Following the annual stockholders' meeting of the Crescent Refractories Company of Curwensville, Pa., announcement was made of a merger of the George S. Good Fire Brick Company and the Clearfield Clay Working Company with the Crescent Refractories Company's properties. Consolidation of these properties brings together three important Clearfield county fire clay and coal holding properties. The output of the plants now operated by the corporation reaching 240,000 brick per day and marks another step forward in fire clay industry of this region. James B. Graham, president of the Northern Trust Company of Wiliamsport, Pa., has been elected president of the board of managers of the Crescent Refractories Company of Curwensville, Pa.

Carl A. Wendell, for the past few years chief engineer of the American Ore Reclamation Company, 71 Broadway, New York, and previous to that connected for several years with the U. S. Steel Corporation, has been retained by the General Briquetting Company as consulting engineer, in connection with their flue dust and ore biquetting development. He will also specialize in coal washing and, as a natural adjunct thereto, in coal briquetting.

The W. R. Miller Company, formerly of the House Building, have moved to their new office building, Boggs and Jasper streets, Mt. Washington, Pittsburgh, Pa. The new phone number is Hill No. 439. Ten minutes ride from Fifth avenue and Wood street to South end of tunnel.

Cutler-Hammer Company annunce that G. S. Crane, who has been manager of the Cleveland office, will become manager of controller sales at the main office in Milwaukee. L. B. Timmerman will be in charge of the Cleveland office, and will act in the capacity of assistant to A. G. Pierce, manager of the Central District. The Cincinnati office will become a part of the Central District with R. I. Maujer as branch manager. E. N. Lightfoot will assume the title of manager of the heating department, with headquarters at the New York works, and will be in full charge of all matters relating to the sale of electrical heating devices.

Effective at once, Robert C. Weller is appointed general sales manager of The Lakewood Engineering Company, with headquarters at Cleveland. Mr. Weller is in full charge of sales work.

Effective March 1, Mr. Carlton R. Dodge is appointed Western sales manager of The Lakewood Engineering Company, with headquarters at 1215 Lumber Exchange Building, Chicago.

Freyn, Brassert & Co., Chicago, have been given a contract by the Rogers Brown Iron Company, Buffalo, for work in connection with the remodeling of their No. 1 furnace. The general arrangement of the furnace, below the mantle, inclusive of bustle pipe and tuyeres, is to be changed and new hearth jacket, tuyere jacket and iron and steel work for both is to be placed. There will also be material modfication and enlargement of furnace lines and capacity.

Lawrence Wilkerson Wallace was elected secretary of American Engineering Council at the meeting of the executive board in Syracuse, N. Y., on February 14, succeeding L. P. Alford of New York, who has been acting secretary since the formation of the council in Washington on November 19, 1920. Mr. Wallace has been one of the most active figures in the council and from the time it was organized has been its treasurer. As vice chairman of the council Mr. Wallace has been directing the work of the committee on elimination of waste in industry, one of the principal committees of the council whose scope following the Syracuse meeting will be greatly broadened.

TRADE PUBLICATIONS

Frank D. Chase, Inc., Chicago, have recently compiled and issued a highly interesting and illuminating booklet entitled "Factories That Fit." The purpose of this booklet is to get across the Chase conception of sound engineering design in factory construction.

The Griscom-Russell Company, 90 West street, New York, has recently published a 29-page illustrated booklet entitled "The Cooling of Quenching Oil in the Heat Treatment of Steel," by Kenneth B. Millett. This describes in a very readable manner the necessity for heat treatment, the various quenching mediums and systems commonly used, the advantages of continuous circulation of the medium and the excellent adaptability of the multiwhirl cooler to the cooling of quenching oil. Typical installations are featured, showing the layout of the piping with recommendations for the proper size and number of coolers to meet the requirements.

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The Plants of the Weirton Steel Company

Description of the New Steel Plant, Including Blast Funace, Open Hearth Furnaces and Mills for Producing Sheet Bars, Billets and Slabs.

By C. H. HUNT,
Chief Engineer Weirton Steel Company.

THE plants of the Weirton Steel Company, Weirton, West Virginia, representing the development of an important independent steel company, are an interesting example of the evolution of a tinplate manufacturing company starting with a finishing plant only, broadening its operations by the addition of other lines of finished products to those which it set out to manufacture, and finally reinforcing its position by the addition of facilities for the manufacture and control of the materials entering into the various finished products from iron ore and other raw materials, until ready for delivery in their highly finished state.

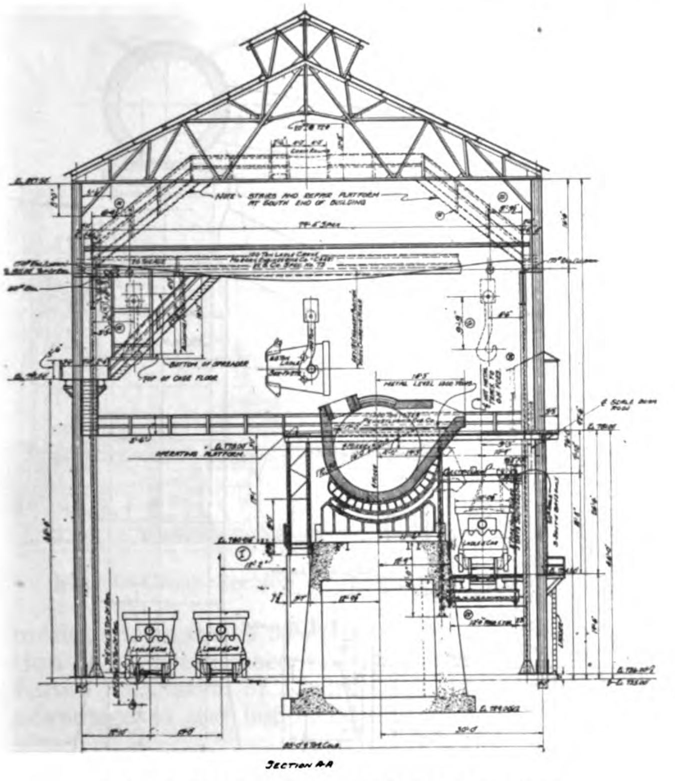

Fig. 1—Section Through Mixer Building.

The company then known as the Phillips Sheet & Tin Plate Co., had its beginning at Clarksburg, W. Va., in the starting of a six mill tinplate plant in July, 1905, four years later the company purchased a site on the West Virginia side of the Ohio river, four miles above Steubenville, O., along the Chester Branch of the Pennsylvania Lines and a short distance from its junction with the main line of the P. C. C. & St. L. Division, and commenced the erection of a 10-mill tinplate plant, marking the beginning of the present main plant and the town of Weirton, which now has a population of about 10,000 persons.

The tin mill plant at Weirton was started in February, 1910, and has since been increased to a 26-mill plant by the addition of 10 mills the latter part of the same year and 6 more to the present time.

An important addition was secured to the company in January, 1912, by the purchase of the Pope Tin Plate Plant at Steubenville, O., consisting of 12 mills and 20 tin stacks, so that including the additions to the Clarksburg plant, the company is now operating 50 tin mills and 100 tin stacks, being the largest independent tin plate manufacturer in the country.

In June, 1915, the company purchased a cold rolled strip steel mill, which was started in Weirton in 1913 and then known as the Weirton Steel Company, consisting of 18 cold rolling mills and immediately commenced preparations for the addition of a 6 inch hot band mill with two 12 feet 0 inch by 45 feet 0 inch Laughlin continuous heating furnaces, 20 inch roughing, 16 inch duo strand and 16 inch finishing mills; also a 10 inch hot band mill, consisting of 11 foot 0 inch by 40 foot 0 inch Laughlin continuous heating furnace, a 6-stand 14 inch continuous roughing mill, 10 inch duo strand and 10 inch finishing mills, the former being placed in operation in December, 1916, and the latter in May, 1918.

This cold rolling department was likewise increased in the early part of 1917 by the addition of 22 cold mills, annealing, pickling, shearing, polishing, oiling and other finishing departments, so that the company now operates 40 cold rolling mills, finishing flat cold rolled steel in all forms from 16 inches wide down and in thickness down to .002 inch and hot rolled bands 1 inch to 16 inches wide of all thicknesses from No. 20 gauge and up on narrow sizes and No. 16 gauge and up on wide sizes.

Plans and calculations were started for the construction of a steel plant, as soon as conditions, which were then abnormal due to the war, would permit. The country was faced by an enormous shortage of pig iron needed for the production of war materials and munitions, the company decided to proceed with the construction of the present 600-ton blast furnace, which was blown in July 21, 1919, and has previously been described in the technical press, except for the changes which have been made to the boiler and power houses in connection with the building of the steel plant and in the method of handling hot metal from the furnace.

The steam generating and power plants for the operation of the blast furnace having been planned for case of extension to serve as the central power and pumping station for the entire projected developments, being located at the blast furnaces to secure the maximum advantage of steam and power generated from waste gases from the furnaces.

An analysis of the consumption of the finishing mills indicated that there would eventually be required steel making capacity for 65,000 to 70,000 tons of ingots per

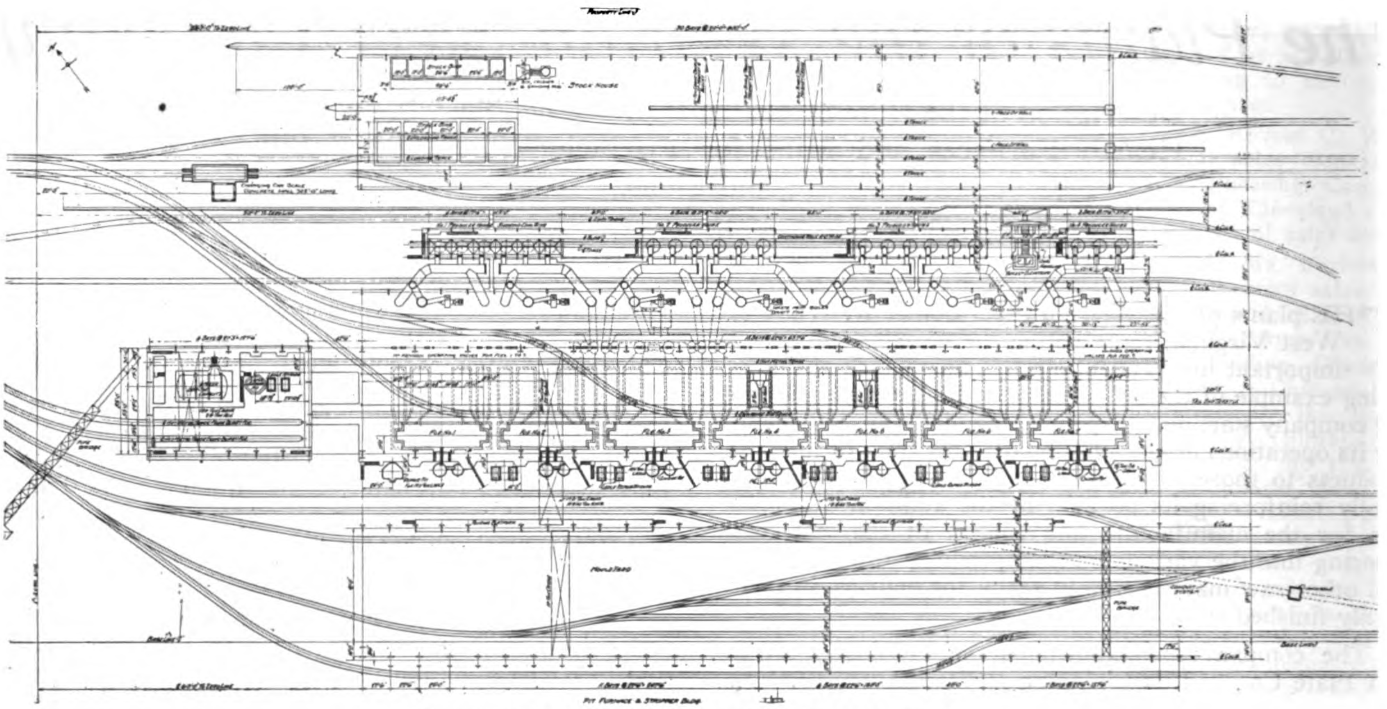

Fig. 2—General Plan of the Open Hearth Plant.

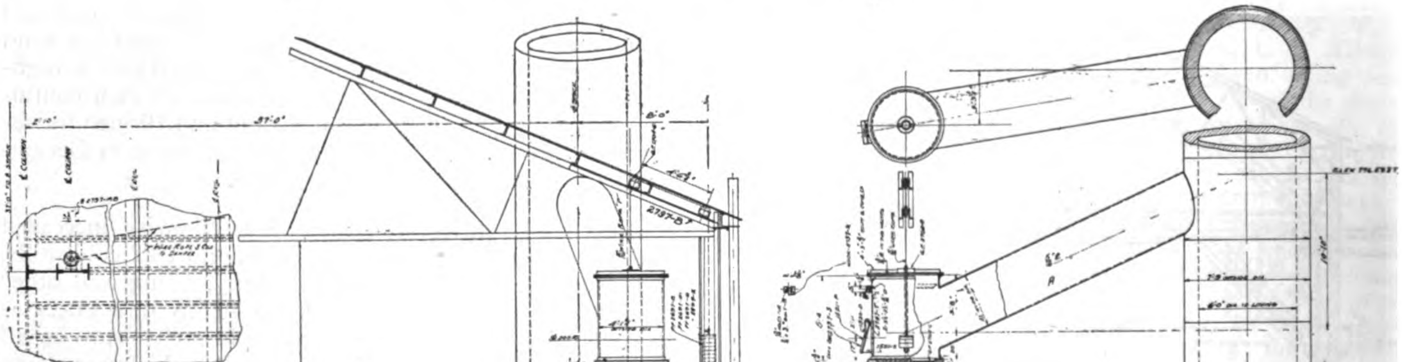

Fig. 3—Waste Heat Boiler Setting.

month and the entire steel plant and blast furnace layout was designed to meet these requirements, the open hearth plant being designed for the ultimate installation of fourteen 100-ton stationary furnaces, the present installation of seven furnaces comprising one-half of the intended plant.

The amount of scrap produced in open hearth practice is about 10 per cent, therefore the amount of metal necessary to supply seven furnaces would be about 38,000 tons per month, of this amount the present 600-ton blast furnace will produce not less than 17,000 tons of molten iron per month, leaving a balance of 21,000 tons of cold metal in the form of scrap of various kinds and some pig iron to complete the charge. The blast furnace, steel plant and finishing mills, will produce a total of 13,000 tons, leaving to be procured from outside sources about 8,000 tons per month.

On completion of the 14 furnaces, the hot metal and scrap requirements would be doubled so that the additional blast furnace would be required to supply hot metal and since the scrap production would be increased in about the same proportion, there would still have to be procured from outside sources about 16,000 tons per month and as this is more than equivalent to the production of a blast furnace, provision has been made for the future installation of a third furnace, should it prove of advantage to use hot metal instead of purchasing this scrap.

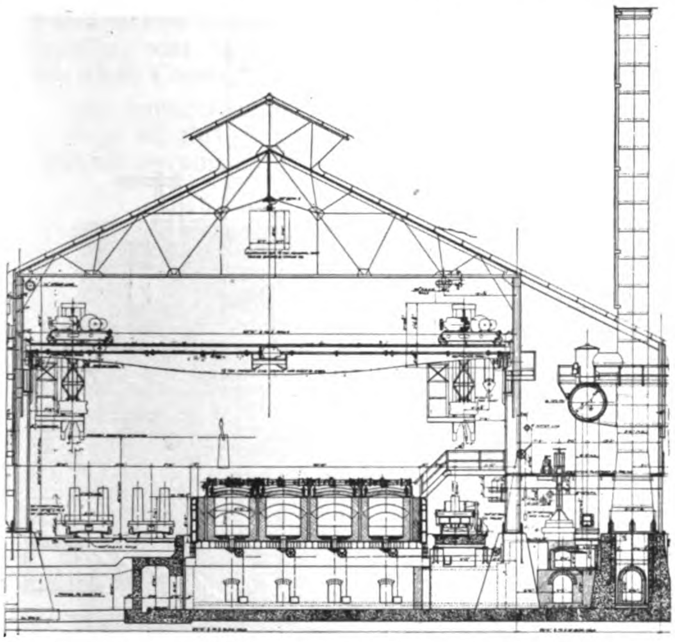

Fig. 4—Cross Section Through Pit Furnace Building.

The company has iron ore interests supplying a large quantity of the ore required for the present blast furnace, which amounts to approximately 400,000 tons per year. This ore is handled at present by discharging from the bottom of cars carried on overhanging brackets on the ore yard side of the stock bins and is handled to and from the stock piles by two 30-40 ton Brown locomotive cranes. For three furnaces there would be required 1,300,000 tons per year, which must be brought down from the mines during not to exceed seven months' navagation season on the Great Lakes, and unloading facilities must be provided at the furnaces to unload this ore and storage space for not less than six months' supply to cover the period during which navigation is closed. Therefore provision has been made for the future installation of a car dumper, movable the length of the storage yard, which will have a capacity for unloading thirty 280,000 pound cars per hour, including weight of cars, delivering their contents over the edge of the ore wall, and for ore bridges having a span of over 200 feet equipped with trolleys carrying 15-ton grab buckets for moving the ore back on to the storage piles, which can be 70 feet high and 1200 feet long between the car dumper wall and the furnace stock bins, and also reclaim the ore from the stock piles and deliver it to a larry car or direct to the furnace stock bins.

The company at present has through its interest in the Redstone Coal and Coke Company, in the Connellsville region, a sufficient supply of beehive coke for the requirements of the present blast furnace.

To provide for the future, upon the completion of additional blast furnaces, since each blast furnace requires from 180,000 to 200,000 tons of coke per year which is equivalent to the production of one battery of by-product coke ovens, provision has been made for the future installation of three batteries of ovens with complete by-product plant, which will be located on the river bank paralleling the Weirton tin mills, with arrangements for receiving coal by river and unloading it from barges and delivering it to the crushing and pulverizing plant on the bank 88 feet above the river.

A storage space has been provided for 130,000 tons as assurance against low or frozen river and other contingencies.

Provision has been made for a complete by-product plant for reclaiming tar, light oil, ammonium sulphate, benzol, toluol and solvent naphtha from the gas distilled from the coal in the ovens. The supply of gas not required for heating the ovens will be available for use in the furnaces at Weirton tin mill and for heating furnaces at the steel plant.

It is contemplated that the coke when pushed from the ovens and quenched will be delivered to a conveyor belt and elevated to a screening tower, flowing from the screens into a specially built electric driven car, to operate on a high trestle track and to connect with the track over the storage bins at the blast furnace, delivering the coke direct to the bins at the furnace skips.

The company also owns a large tract of coal land which is suitable for supplying the various needs of fuel at the plant and therefore have provisions for practically all raw materials and facilities for the complete control of the quality of steel entering into the various finished products of the company.

The accompanying general layout map shows the relation of the various units of the plant to each other and to the Weirton Tin Plate Plant and Strip Steel Plant, also indicating in dotted lines the provisions for extensions to the departments of the steel plant and blast furnace and the location of the future by-product coke plant.

In view of the peculiar shape of the property available and its location on the opposite side of the Pennsylvania Railroad from the existing plants, a problem, which has been successfully worked out, was presented in the efficient grouping of the units of the plant to secure the most economical arrangement of transportation facilities for delivery of raw materials to each department as required, for the shortest and most direct inter-department movement of materials during process of manufacture, and the delivery of sheet bar, slabs and billets to the finishing mills or to the railroad, and to so lay out these tracks that they would be adaptable to all future uses and extensions with the least change or interference with operations, particularly since standard gauge track and rolling stock have been used throughout the plants.

Due to the lack of railroad facilities at the present time in the vicinity for the storage and classification of inbound freight and outbound materials or empties, the further necessity was imposed for the construction of a storage and classification yard of sufficient size to serve the requirements of the plant, this yard having a capacity of 400 cars.

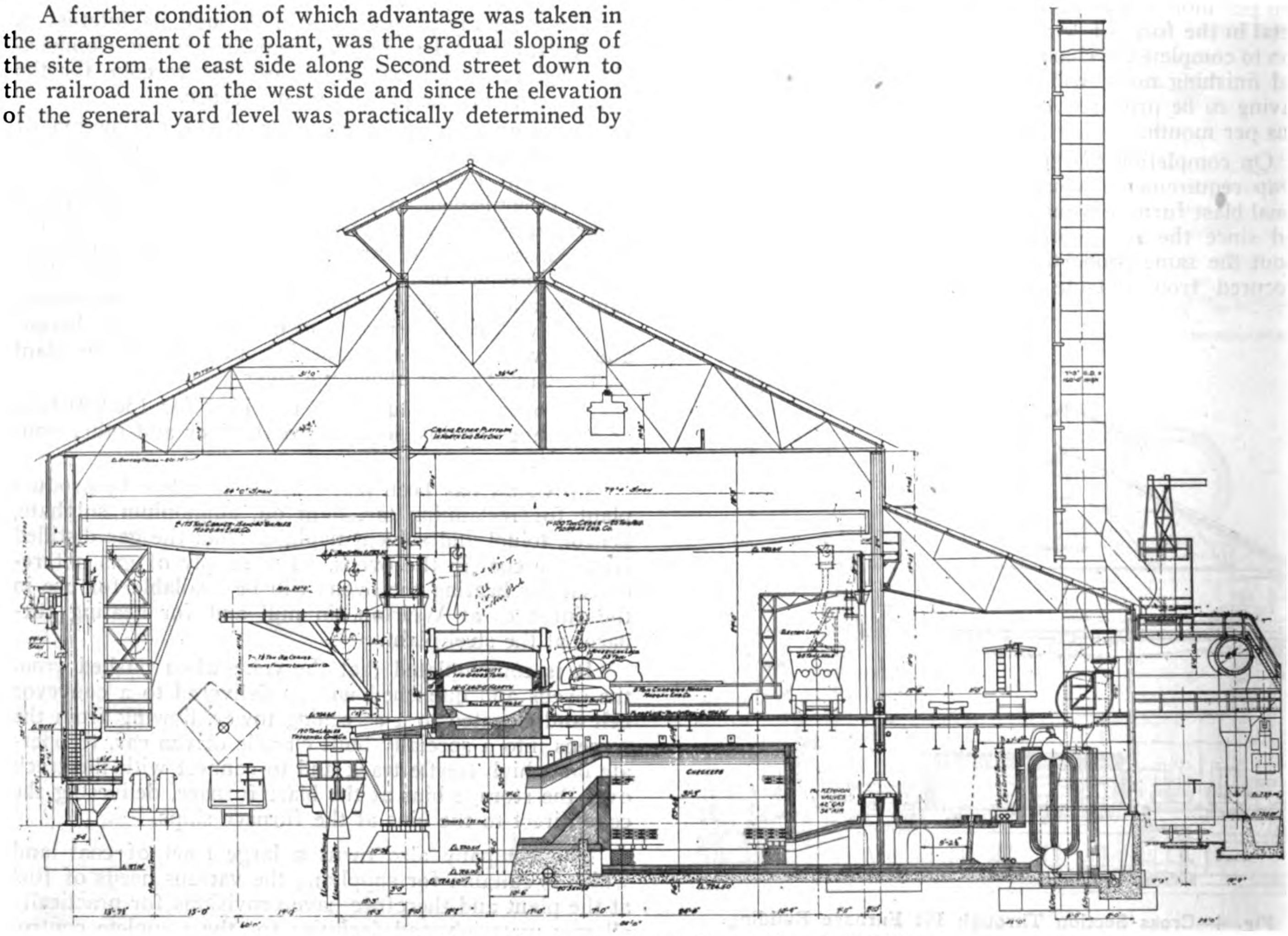

Fig. 5—Cross Section Through Open Hearth Building.

A further condition of which advantage was taken in the arrangement of the plant, was the gradual sloping of the site from the east side along Second street down to the railroad line on the west side and since the elevation of the general yard level was practically determined by the elevation of the railroad line, in order to secure an easy gradient of approach from the railroad. It was necessary to remove over 140,000 cubic yards of earth to bring the plant site to the proper level, and by locating the open hearth stockyard on the high ground parallel to Second street, to save a great amount of excavation and to maintain the charging tracks in the stockhouse on the same level as the open hearth charging floor, a very great advantage in the transportation of the trains of charging cars from the stockhouse to the open hearth, particularly in wet or snowy weather by eliminating the usual long graded fill or trestle approach with its consequent delay and added cost of motive effort.

The arrangement, which is clearly shown in the accompanying cross section and plan of the open hearth plant, permitted the parallel arrangement of the gas producer houses and stockyard back of the open hearth charging bay and the consequent ease of extension of these buildings in accordance with the extensions to the open hearth building, it being the intention on completion of the plant to its ultimate length to also provide a connection at the south end from the stockhouse to the open hearth charging floor for ease and avoidance of congestion in bringing cold stock to the furnaces at this end of the plant.

All inbound materials enter the plant at the southwestern entrance and are delivered to the storage yard or go direct to the point of consumption; ore, limestone and for the present coke, are taken from the yard over a graded approach track to the high level tracks over the stock bins at the blast furnace, coke and limestone being unloaded direct from the cars into their respective pockets and the ore during the season of its movement, either direct to the ore pockets or to the unloading track for movement to the storage piles, and upon completion of the future ore handling equipment, will go forward from the yards to the car dumper, all outgoing empties being returned to the railroad from this end of the yard to avoid interference with incoming material.

The movement of scrap to the stockhouse and coal to the gas producers of the stock plant, is from the southern end of the yard as can be seen by reference to the general layout and arranged to permit the free movement at all times of steel outbound from the mills.

Hot metal will move from the pouring tracks between the furnaces and boiler house to the mixer at the north

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end of the open hearth building, while casts not required at the open hearth plant may be poured direct from ladles on cars into the Pittsburgh coal washer pig machine located at the end of the cast house of the present furnace, where prior to the completion of the steel plant it was arranged for running metal direct to the pig machine, while the plant was operating as a merchant furnace. The temporary iron runners and ladle stands having been removed and replaced with runners to three spouts at the side of the cast house to pour into 65-ton Pollack ladles and cars. Pollock short pour ladle stands are placed at the pig machine to suit the ladles on cars, which are poured by the Whiting crane in the present cast house.

The entire steel plant was designed and built under the direction of C. H. Hunt, Chief Engineer of the company, under its operating head, J. C. Williams, vice president and general manager in charge of operations, the engineering organization of the company having prepared all plans, specifications and details for the steel plant and the general layout of the entire plant, including the blast furnace and provisions for the future coke plant.

All excavations, foundations, fill, brickwork and installation of the machinery and equipment was done by the company under the supervision of the Jack Walsh Construction Company. All structural steel work for the building was furnished and erected by the McClintic-Marshall Construction Company.

An unusual record was established in the building of a plant of this magnitude, particularly in view of the difficult circumstances affecting the manufacture and delivery of equipment during the period of construction occasioned by the coal strike, switchmen's strike and the steel strike and the extreme rigor of the winter of 1919 and 1920, as foundation work for the plant was started on June 15, 1919, the first heat of steel was poured at the open hearth November 22, 1920, and the first three ingots drawn rolled all the way through the mills as commercial sheet bar November 29, 1920. Therefore in spite of the difficulties encountered, the plant was completed and in operation within 17 months of commencement of construction.

Hot metal is brought from the blast furnace to the mixer building in 65-ton Pollock ladle cars drawn by an 80-ton American yard locomotive and is weighed on a 200-ton railroad track scale, furnished by the Strait Scale Company, located just north of the mixer building.

It was decided instead of installing a mixer of small capacity for the present plant and later adding an additional mixer, to serve the requirements of the additional furnaces, to install at the beginning a mixer of sufficient size for the ultimate requirements, and this mixer of 1300 tons capacity and at present lined down to 1000 tons, is of the cylindrical type and was furnished by the Pennsylvania Engineering Company. It is housed in a separate building at the north end of the open hearth and separated therefrom by an intervening space of 22 feet 6 inches, being 127 feet 6 inches long by 85 feet center to center of columns and 92 feet high from yard level to the underside of the roof chords.

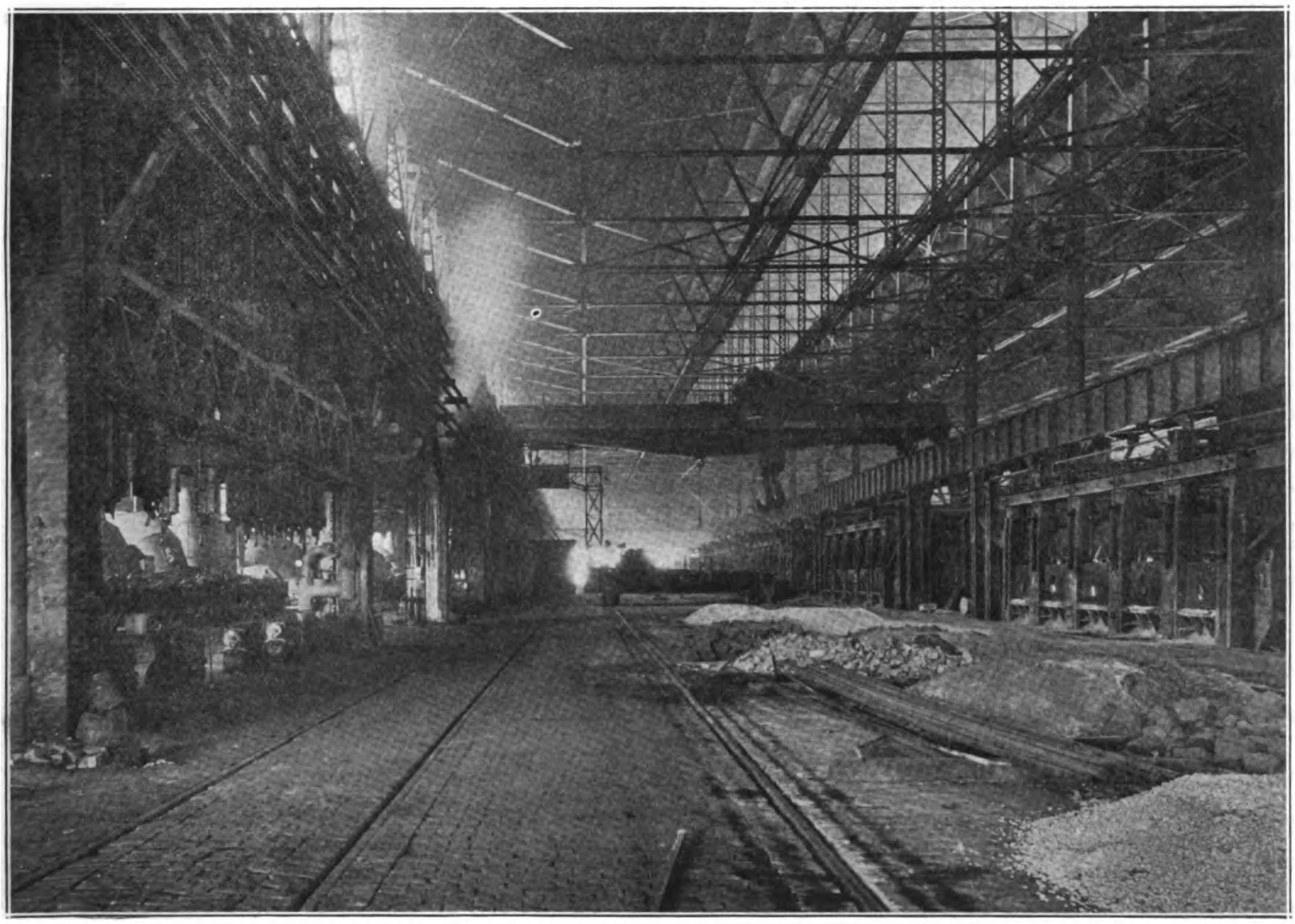

Fig. 6—Charging side of the open hearth plant showing furnaces No. 2 to No. 7, inclusive.

The mixer is electrically operated by two 87½ hp motors, connected in series, and either motor is of sufficient capacity to operate the mixer in case of trouble with the other. The receiving spout cover is operated by hoisting mechanism driven by a 7½ hp motor. The control masters for all motors and the magnetic panel for the main motors are located on the operating floor and totally enclosed in a brick structure to protect all parts from the accumulation of dirt.

The center line of the mixer is 43 feet above yard level, the metal being lifted and poured into the receiving spout by a 10-ton Morgan crane, equipped with 25-ton auxiliary, the crane having a span of 79 feet 4 inches and the height of the crane runway from yard level being 76 feet.

The delivery side of the mixer is on a line with the charging side of the open hearth building and is at the same elevation or 19 feet 6 inches above yard level. From the mixer the metal is poured into 65-ton ladles of the same design as those used in bringing metal from the blast furnace to the mixer. The ladle car stands on a weighing scale platform while being filled, the metal being weighed also as it leaves the mixer, the weigh platform is connected by four suspension rods to the scale beams, which are installed overhead and just under the operating platform to avoid damage in case of a spill of hot metal from the mixer while pouring, the weigh beam being located in the same house with the control. This scale is of 150-tons capacity and was furnished by the Fairbanks Company.

The operator when pouring is located in one end of the control house with the scale beam at his side and has a clear view of the mixer and the ladle through a novel arrangement of windows in the control house and grating in the operating floor.

Ample escape platforms and runways have been provided for the mixer operators and cranemen, escape runways also being provided on the outside of the building at the levels of the crane cage and pouring floor with revolving doors conveniently spaced in the sides of the building to allow the men to get outside in case of a serious spill within the building.

A Baldwin-Westinghouse electric locomotive hauls the hot metal ladle cars to the open hearth plant on a standard gauge track located back of the charging machine tracks on the open hearth floor.

The open hearth department comprises seven of the 14 eventual furnaces, housed in a building 190 feet wide by 637 feet 6 inches long with a height from yard level to bottom chord of roof trusses of 66 feet 9 inches. The width is made up of three aisles, the pit on the pouring side of the furnace is 60 feet wide, the charging bay proper is 85 feet wide and is supplemented by a leanto on the gas producer side 45 feet wide, containing a continuation of the charging floor which is 19 feet 6 inches above yard level.

The furnaces are constructed to nominal 100-ton lines but have sufficient hearth area, being 16 feet wide by 40 feet long to melt 120 tons at a heat, for which ladle capacity has been provided, in fact to test the capacity of the furnaces, a 130-ton heat has already been successfully poured and due to this tremendous melting capacity, the furnaces are of very heavy construction throughout, bound with cast steel water cooled buckstays. The furnace bottom is built up from a ¾-inch steel plate pan, resting on a transverse grillage of 15-inch I beams, supported on 12 24-inch 100-pound I beams, placed longitudinally and resting on two massive concrete piers supporting the

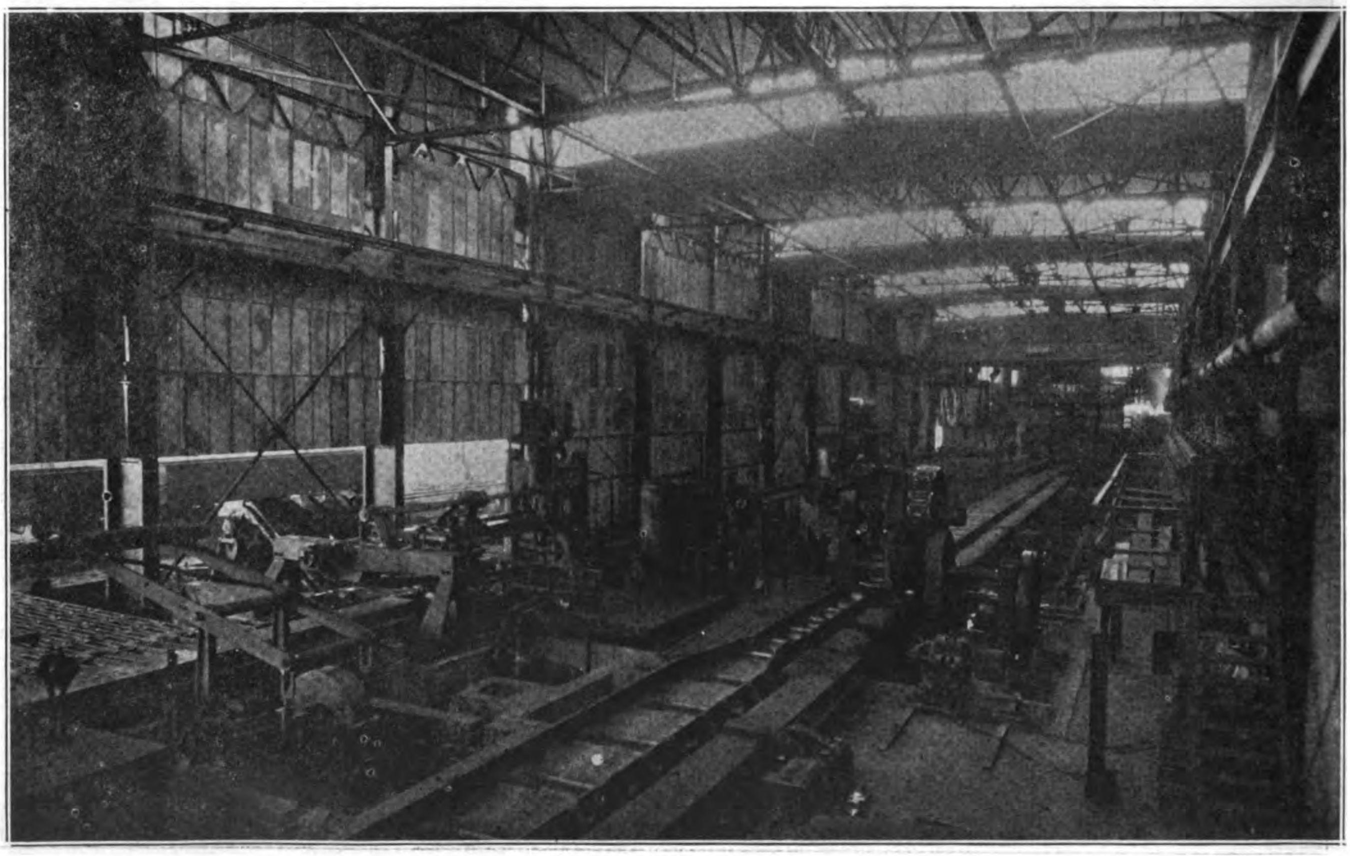

Fig. 7—600-ton steam hydraulic shear and shear table and gauge and 300-ton cropshear looking toward the blooming mill.

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furnace, the ends of these beams being extended as a cantilever over the top of the air slag pocket to support the wind box.

The gas and air regenerators, located back of the furnaces, are built separate 31 feet 3 inches long inside, 20 feet 6 inches high from bottom of flue to top of arch and are respectively 8 feet 4 inches and 12 feet 6 inches inside. The checker work in the chambers is of standard type made of 9x4½x2½ inches first quality fire brick.

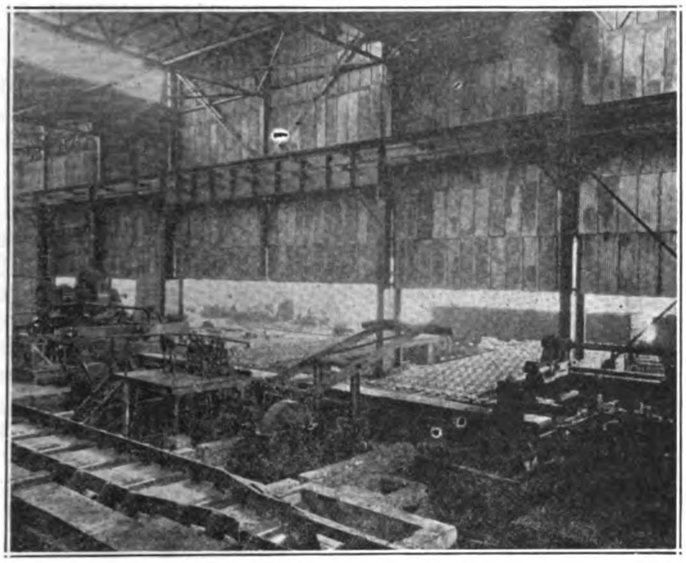


Fig. 7—Slab and billet conveyors showing pushers and operating platform with 600-ton billet shear at the left.

On account of the gravelly formation of the valley in which the plant is located, the ground around the furnaces frequently becomes saturated with water coming down from the hillside, therefore the slag pockets, regenerators, flues and waste heat boiler settings which are provided at each furnace, are built on a concrete pad, the sides of which enclosing the entire area under the charging floor are carried up above yard level, forming a water tight concrete pan. All brickwork resting directly on top of the concrete, which has a slight slope toward the pouring aisle side, rests upon a red brick subbase, constructed to form drain ducts in the direction of the slope, and any water seeping through is thereby discharged into a drain trench without injury to the brickwork, the weight of the binding for the regenerator chambers, slag pockets and the boiler settings also being supported on the concrete pad.

The furnaces are provided with five charging doors and frames of the Knox water cooled type, the three center openings being 36 inches high and 48 inches wide with doors 3 feet 4 inches and 4 feet 8 inches wide, the end openings being 36x36 inches, with doors 3 feet 2 inches by 3 feet 8 inches wide. The doors are operated by motor driven worm gear hoists, furnished by the Pennsylvania Engineering Works. two of the furnaces are provided with Knox water cooled ports, two are equipped with Blair water cooled semi-circular ports with water cooled bulkheads and the remaining three are of the usual dry port construction, equipped with pipe coolers. The gas and reversing valves on furnaces 1 to 6 inclusive are of the McKennon water cooled and water sealed type, the gas inlet and reversing valves at 42-inches and the air reversing valve 54 inches, there being six to each furnace; furnace No. 7 is equipped complete with Knox water cooled damper type valves. All valves are motor operated, no hydraulic power being used in the open hearth department, avoiding trouble with frozen lines, therefore a special type of drive was developed by the company for the operation of the McKennon valves, the motor drives of this equipment being located between the mail building columns back of the charging floor and are equipped with a special hand adjustable electric cut-out arrangement, governing the amount of opening to the valves which allows the melter to regulate from the charging floor, the differential temperatures of the gas and air chambers.

A novel arrangement of control has been installed for operating the valves and doors, the controllers being placed over head on girders spanning between the main building column, allowing free passage way underneath, the control for two furnaces being grouped together, the valve control for one furnace being at one end and for the other furnace at the opposite end, with the door control for the two furnaces located at the center of the girder. The steam control valves to the gas producers and the draft control on the open hearth boilers are also located here, so that it is all convenient to the melter, without crossing tracks in the leanto congested with stock trains.

A waste heat boiler is installed at each furnace for utilizing the heat in the waste gases from the furnace. Steam is developed at 225-pound pressure, some of which is used in the gas producer plant for blowing the producers, and the remainder delivered to the main steam line, which passes down through the open hearth building along the main columns back of the charging floor, connecting the boiler plate at the blast furnace with the engine at the blooming mill, so that this steam can be utilized either at the blooming mill or at the power house in case the mill is down.

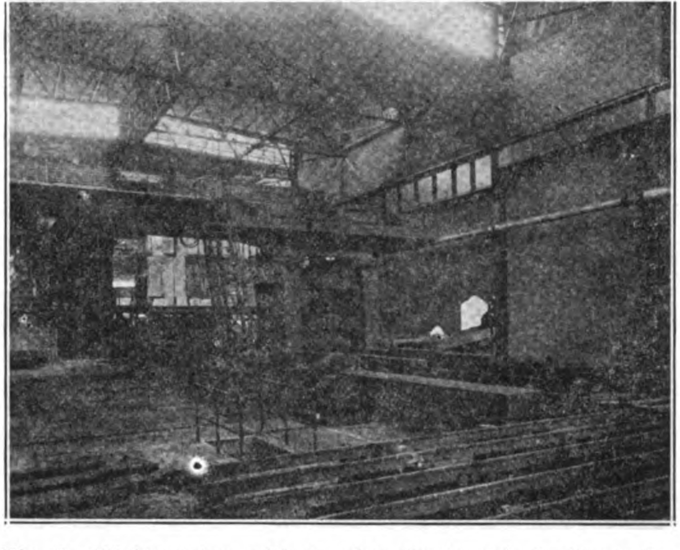


Fig. 8—40" blooming mill showing Mesta univehsal spindles connecting with the pinion housing.

The boilers are of the vertical water tube type of 600 hp rating, built by the Erie City Iron Works. The boilers are located on the center line of the furnace underneath the leanto floor as close as possible to the valve in order to avoid the loss of heat. A by-pass flue is provided to a bell bottom stack 6 feet inside diameter by 160 feet high, furnished by R. Munroe and Sons, Pittsburgh, each flue being provided with a chain block operated Knox water cooled valve with water cooled seat for sealing off direct flow of gases to the stacks. A chain block operated dry hammer is also installed in the flue leading to the boilers. Foster super-heaters, furnished by the Power Specialty Company of New York are installed vertically in the flue at the entrance to the boiler, designed to super-heat the steam to 125 degrees, corresponding to the super-heat carried at the power house and throughout the steam system. The boilers are also equipped with Diamond Power Specialty Company soot blowers for cleaning the boilers and two elements are installed in connection with each set of superheater tubes.

Mechanical draft for the boilers is provided by a specially designed motor driven fan, mounted on the extension of the charging floor in the leato bay, directly above the boiler breeching; a connection from the fan in which is installed a valve for sealing off the boiler when not in use, delivers the gases into the furnace stacks. The fans were furnished by the B. F. Sturtevant Company and are driven by 100 hp constant speed ac motors. They are of full housing, double inlet type, specially designed to prevent the collection of soot to destroy their balance and provided with a through shaft carried in water cooled bearings on each side of the fan. A special air cooled shield surrounds the shaft on the inside to prevent unbalance due to warping of the shaft. As an additional precaution against vibration, the section of the floor immediately surrounding the base of the fan was filled in solid with concrete. The fans are designed to give a maximum static pressure of 5 inches when delivering 120.000 pounds of gas per hour. A damper is located in the outlet from the boiler, connected to an operating stand on the main column back of the charging floor at the control station, where the draft on the furnace may be regulated. The boilers are fitted with Copes feed water regulators, the treated water after being heated in the main heating plant at the blast furnace boiler house, is delivered at low head through an insulated line to a point central to the final open hearth layout and delivered into a tank on the charging floor level, from which one of two 4-inch Jeanesville centrifugal boiler pumps deliver the water to the boilers. These pumps are driven by 125 hp Moore steam turbines, the exhaust from the turbines being introduced into the tank which receives the treated water, making up for any loss of heat coming through the supply lines from the heating plan at the boiler house and imparting additional heat to the water.

For charging the open hearth furnaces with scrap, ore and other materials, there are two 5-ton low type Morgan charging machines with a span of 24 feet 6 inches for handling the charging boxes, which are run in from the stock house on a standard gauge track in front of the furnace doors. Hot metal is brought in from the mixer building on a ladle car over a standard gauge track, between the charging machine track and the main building column to a point opposite the furnace and is lifted by a 100-ton Morgan ladle crane, having a span of 79 feet 4 inches and provided with a 25-ton auxiliary trolley for pouring.

Two tracks traverse the leanto and afford storage for stock trains ready to be charged. Crossovers are provided for every three furnaces with the charging car track in front of the furnaces. Connection is made with the high level tracks in the stock house at the north end of the building by a steel bridge and on completion of the 14 furnace layout, a like connection will be provided at the south end of the plant,

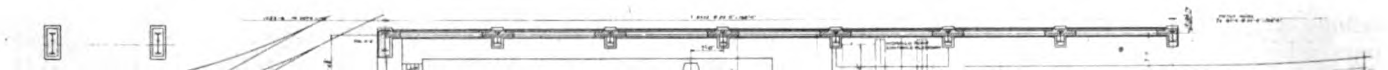


Fig. 9—General layout of

with crossovers arranged in the opposite driection.

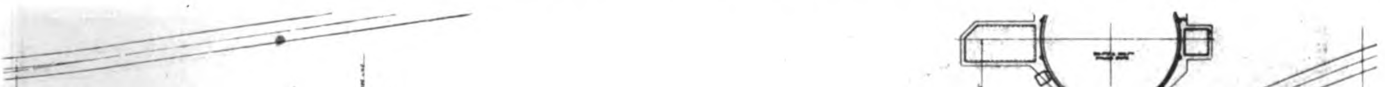
The pouring floor is traversed by two tracks; the track nearest the furnaces is a through service track used for handling cinder, skulls, refuse, etc.—the track near the outside column is used for spotting the ingot moulds for pouring the steel. Two pouring platforms are provided alongside the building columns adjacent to this track and crossovers are provided between the pouring platforms so that the ingot trains may be drawn out from either end as provision has been made for spotting ingot moulds for two heats at each platform. Two 175-ton Morgan ladle cranes, each having a 40-ton auxiliary trolley, equipped with a 15-ton auxiliary hoist, are provided for handling the 120-ton ladles on the pouring side. Cinder pots of 260 cubic foot capacity are mounted on stands alongside the ladles when in pouring position to receive the overflow of cinder from the ladles.

The steel ladles, cinder pots and cinder cars were furnished by the M. H. Treadwell Company. The ingot moulds are mounted for pouring in a double row on cars designed for carrying six moulds and furnished by the Wheeling Mould and Foundry Company. These cars are equipped with Hyatt Roller Bearings. A 7½-ton jib crane, made by the Whiting Foundry and Equipment Company is attached to the building column at each furnace for handling the pouring spout. Over both the charging floor crane and pit cranes for repair purposes, there is a 7½-ton monorail trolley, furnished by the Toledo Bridge and Crane Company, louped at the end of the building so as to serve the cranes in either aisle.

Ample platforms and walkways surround the crane runways accessible by stairways leading up from the charging floor and an escape platform is provided for the ladle crane operator on the pit side directly above the pouring platforms and extending the entire length of the building to allow the operators to escape with safety in case of a bad spill.

Producer gas is the fuel used in the open hearth furnaces and the gas plant consists of 21 Morgan mechanical producers equipped with automatic measuring feed and self-cleaning ash pans. The producers are arranged in batteries of six, three for each furnace, each battery being housed independently in a steel building 105 feet long, 22 feet wide, center to center of columns. The operating floor of the producer houses is on the same level as the open hearth charging floor and the stock house, and at each battery house are provided foot bridges connecting with the open hearth charging floor and the stock house. The connection from the gas producers to the furnace flues is by means of overhead gas mains, three producers being separately connected to each furnace. An overhead burnout connection is installed between each main and the furnace stacks—the gas mains are insulated with a 2½-inch lining of Sil-O-Cel brick between the steel plate and the 4½-inch fire brick lining to prevent loss of sensible heat in the gas due to radiation, the diameter of the mains being 5 feet 8 inches inside of brickwork.

Opposite each producer ample dust legs are provided which extend down to the foundation also serving as supports for the mains. The connection of the goose neck from the producer into the dust leg is so arranged that the gas is deflected downward before rising up into the main, the reversal of direction throwing down into the dust leg the greater part of the soot and dirt which comes over with the gas and has proven of material benefit in keeping the mains and flues free from these deposits. Steel walkways have been provided along the top of the mains with ample platforms and stairways for access to



upper end of the mill.

burnout connections, doors and lance holes. The entire system of gas mains and walkways was furnished and erected by the William B. Pollock Company.

The coal handling system was furnished by the C. O. Bartlett & Snow Company and is located at the center of the ultimate line of producer houses. Coal is received on a track between the producers and the stock house retaining wall and is run from the bottom of the cars into a track hopper, located underneath this track at the coal hoist, from the track hopper the coal is conveyed by a 26-foot wide apron type conveyor, having a capacity of 150 tons per hour, operating at a speed of 30 feet per minute, to a 24x24-inch two roll crusher, which delivers it into a hopper discharging into two skip buckets of 120 cubic feet capacity, which automatically elevate the coal into a 500-ton overhead storage bin.

Gates are provided in the chutes leading from the hopper to the skip bucket, arranged in such a manner that they are automatically closed at all times except when the skip bucket is in a position to receive coal. As soon as the skip becomes loaded to the proper level, it settles by weight onto an arm which automatically starts the hoist, one bucket being lowered into position as the other is elevated. Screens are provided at the top of the hoist for screening out fine slack coal which is discharged into a central pocket of the storage bin from where it may be returned to a car on the receiving track and sent to the boiler house, by this arrangement only coal of a suitable size need be charged into the producers.

A chute is also provided for coaling the locomotives which handle the stock on the charging floor level between the stock house and the open hearth. From the storage bin coal is drawn through air operated valves in the bottom of the bins, of which there are five, into a 10-ton center bottom dump electric transfer car, equipped with scales for weighing the coal, furnished by the Atlas Car and Manufacturing Company. The transfer car travels the length of the producer plant, bridges spanning the intervening space between the producer houses, and discharges the coal into individual hoppers over each producer having a capacity of 38 tons, out of the bottom of which the coal flows as required to the automatic feed of the producers.

On the furnace side of the gas houses located between the building column piers and the piers for the dust legs, is a concrete trench extending the length of the gas house into which the ashes are automatically blowed from the ash pan to the producer. The dust which collects in the dust legs is discharged through a bottom bell valve, operated from the producer floor into the same trench, mixing with the ashes. A monorail bucket trolley furnished by the

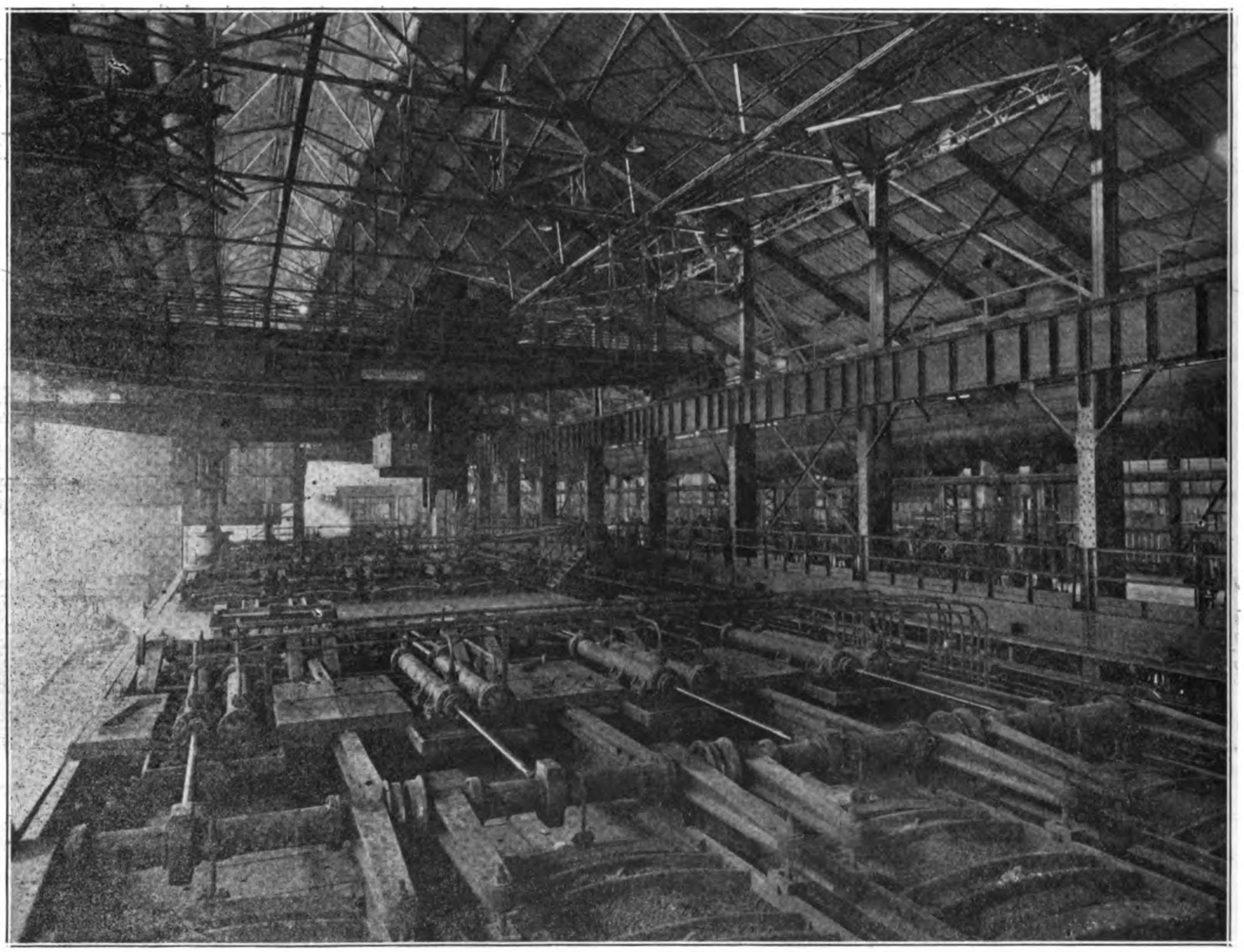


Fig 10—Five of the six soaking pit furnaces with regulating and receiving valve platform at the right, showing blooming mill in the background.

Toledo Bridge and Crane Company, carrying a 1¼ cubic yard Hayward bucket, travels on an I beam track over the ash trench, removing the ashes from the trench, loading them into a standard railroad car on the track between the producer house and the furnace building, the monorail curving out over the track at a point opposite the coal hoist. This novel arrangement for handling the ashes, together with the system for handling the coal and the automatic feed on the producers, reduces the labor required in this department to an absolute minimum.

The raw materials for charging the furnaces are brought from the stock yard, located in a covered steel building 600 feet long by 103 feet 6 inches span center to center of columns, having a span center to center of crane runway rails of 100 feet. At the north end of the stock house are located reinforced concrete bins for the storage of limestone, iron ore, dolomite, fluerspar, etc., which are built below the level of the stock house, permitting the unloading track to be carried over the top of the bins so that the material which spills over when being dumped from the bucket falls back into the bin avoiding any labor in cleaning up. At this end of the building opposite the main storage bins are installed above floor level, concrete bins for the storage of chrome ore, magnesite bins, dolomite, ferro-manganese, etc., at one end of which is located the crushing and grinding plant, consisting of an 8-foot wet grinding pan and a 10x16-inch Buchanan crusher.

There are two levels extending the length of the stock house, the higher level being on the same elevation as the charging floor of the open hearth and traversed by two tracks inside the building on which the stock trains are loaded and a runaround track outside the building between the retaining wall on the gas producer side and the building columns. These tracks are elevated 5 feet 5 inches above the general level of the stock house, so that the top of the charging boxes on cars is about the same elevation as the top of gondola cars standing on the lower level, this construction being adopted to facilitate the unloading of scrap direct from cars into charging boxes and avoid excessive hoisting and lowering of the magnet.

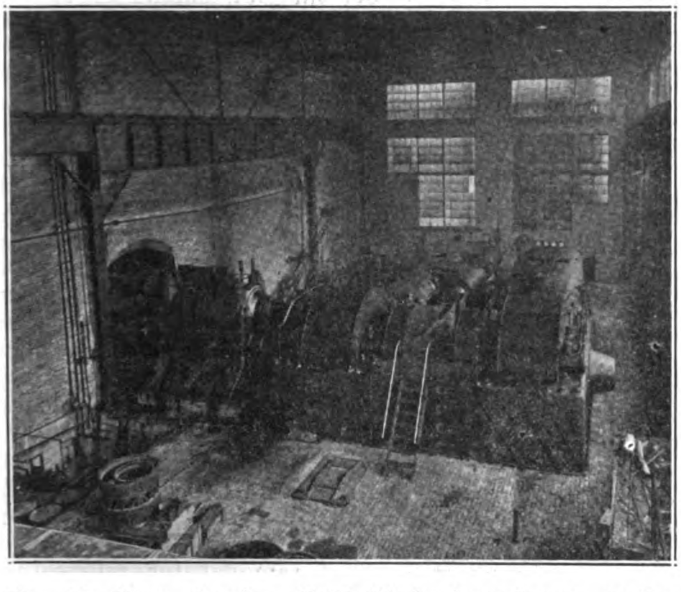


Fig. 11—View showing 42x66x60′ horizontal turn tandem compound reversing engine and blooming mill pinion housing.

Two tracks traverse the stock house on the lower level for handling material coming in on standard railroad equipment. A retaining wall separates the two yard levels and a wall 4 feet high is built alongside the tracks on the lower level to increase the storage capacity which is provided between these tracks and the cast side of the building, there being ample storage space provided under the cranes for 40,000 tons of pig iron.

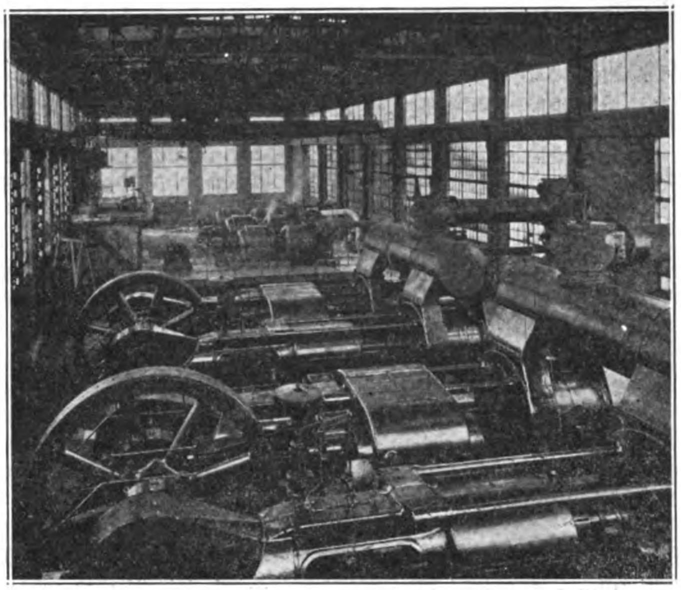


Fig. 12—Showing three 7,500 kw turbine driven generators. Blast furnace blowing engines are shown in the foreground.

The building is served by two 10-ton cranes equipped with single hoists for handling 62-inch Cutler-Hammer magnets and one crane is equipped with a 10-ton magnet trolley and a 10-ton bucket trolley mounted on the same bridge equipped with a 2-cubic yard Blaw-Knox Bulldog type bucket. These cranes were built by the Champion Engineering Company, Kenton, Ohio.

The cinder yard is located about 600 feet south of the eventual end of the open hearth plant and is an open runway 320 feet long by 80 feet wide, center to center of column and is served by a double trolley Champion crane, having a span of 76 feet 6 inches. One trolley is arranged for handling a 3-cubic yard Blaw-Knox Bulldog type bucket and the other trolley is equipped with a 25-ton hoist and a 10-ton auxiliary for handling a 10-ton magnet. The crane runway rail is 44 feet above level and provision has been made to erect in the future over one-half of the length, a runway which will be 67 feet above yard level, to be utilized as a high drop for breaking skulls, scrap, etc. At present the 5½-ton drop ball is handled by the 62-foot Cutler-Hammer magnet.

The pit furnace and rolling mill department is west and parallel with the open hearth building, being separated by a space of 105 feet from center line of open hearth building columns to center line of pit furnace building columns. Crane runways are provided on the outside of each building, and the yard, which is used for mould storage, the cooling and storage of ingot trains, is covered by a 10-ton Champion crane having a span of 99 feet 9 inches for handling moulds and making up trains. The ingots coming from the open hearth are weighed on a 20-ton Strait platform track scale located north of the end of the stripper building.

Six pit furnaces are housed in a building 89 feet wide, center to center of main columns, by 450 feet long, with a 26 foot wide leanto on the west side 292 feet 6 inches long over the valves and operating platform. The crane equipment consists of one 150-ton Morgan screw type stripper and two 7½-ton Morgan soaking pit crane, with 10-ton auxiliary hoists for handling coke buckets, etc., the span of the cranes is 85 feet. A 7½-ton monorail trolley, duplicate of the trolley in the open hearth building, is installed in the roof trusses for repair work on the cranes.

The pit furnaces are all of the four hole regenerative type, each hole 6 feet 3 inches by 8 feet, having a capacity of six ingots; the top of the pits is 7 feet 6 inches above yard level,

Producer gas is the fuel used, each pit being equipped with separate hand regulated water cooled mushroom valves for adjusting the air and gas supply and the reversal of the entire furnace being accomplished by six 36-foot McKennon valves operated by hydraulic cylinders, this equipment was furnished by the Pennsylvania Engineering Company.

The pit furnace covers are mechanically operated and were especially designed to prevent water due to leaks in packing or gaskets from coming in contact with the furnace brickwork and also constructed to minimize warping or burning out due to heat from the pits, and damage to the brickwork around the top of the pit when closing. They were furnished by the Connellsville Foundry, Machine and Steel Casting Company.

Six Morgan mechanical gas producers, duplicates of those installed at the open hearth plant, furnish gas for the pit furnaces. The gas main connecting the producers to the furnaces are insulated with a 2½-inch lining of Sil-O-Cel brick between the shell and the 4½-inch fire brick lining, the main header 6 feet 8 inches inside diameter, of brickwork, is connected at each end of the producer house with a 5 foot 9 inch inside diameter distributing main, supported above the valve operating platform with 3 feet inside diameter downtakes to each furnace. The pit furnace stacks are 4 feet 6 inches inside diameter of brickwork and 95 feet high. A burnout connection is provided at No. 1 and No. 4 furnaces between the gas main and the stacks, as at the open hearth the gas mains are provided full length with ample steel walkways for safe, convenient access to all burnout doors and lance holes. The piping was furnished and erected by the William B. Pollock Company and the six pit furnace stacks by R. Munroe & Sons Manufacturing Corporation.

The coal and ash handling equipment was furnished by the Link-Belt Company, coal being supplied to a yard level track hopper located at the side of the producer house at one end, from which it is delivered by a 24-foot wide steel apron conveyor, having a capacity of 70 tons per hour to a 28-foot diameter by 24-inch two roll crusher, discharging into a Peck overlapping pivoted bucket type conveyor, which elevates the coal passing over the top of the 60-ton individual coal bunkers over each producer, arranged with a tripper for discharging coal into any one bunker as required.

The 18-inch 6-strand continuous sheet bar mill is designed to produce sheet bar 8 inches wide of any weight from 6-2/3 pounds to 46 pounds per foot and is designed to permit of rolling flats up to 15 inches wide. This mill can also be changed over to roll 1¾-inch squares and larger and will roll its range of billets from a 4x4-inch square section, its product of sheet bar from an 8x2-inch slab as delivered from the 21-inch mill, and has a capacity of 60,000 tons per month of 10-pound sheet bar, or 1¾-inch billets.

The mill buildings are of steel and brick construction with high and low bay type roof over the main aisle and including the engine house and motor house, are covered with a cast-in-place monolethic gypsum slab roof furnished and applied by the H. H. Robertson Company, the roof and sides of the slab yard down to a height of 18 feet above yard level, being covered with corrugated steel.

The crane equipment was all furnished by the Champion Engineering Company, the blooming and continuous mill building is served by a 30-ton crane with 15-ton auxiliary hoist and a 15-ton crane, the span of both being 66 feet. The engine house is covered by a 45-ton crane with 15-ton auxiliary, having a span of 50 feet 10¼ inches, while over the sub-station and motor house leanto, a 15-ton crane, span 28 feet 7 inches, is used for general repair work and for handling rolls to the roll lathes, which are located in this department. For handling slabs and billets in the slab yard, a 15-ton crane, 85 feet span, is provided for handling either magnet, chains or special lifting cradle for handling piles of slabs and billets from the conveyor. The sheet bar yard is served by a 15-ton double drum trolley crane, 85 feet span, equipped with a special lifting beam for sheet bar piles.

The blooming mill, manipulator, tables, shears, crop conveyor, pusher and equipment up to the 21-inch mill and up to and including the billet shears, was all furnished by the Mesta Machine Company, with the execption of the slab and billet conveyors, which were built by the Treadwell Engineering Company. The continuous mills and drives, skew connecting table, broadside transfer and billet shear table, Edwards flying shear, piling rolls, bar piler and the combination sheet bar and billet hot bed were furnished by the Morgan Construction Company.

The blooming mill is a two-high reversing mill, with rolls 36 inches diameter by 92 inches long. The screwdown mechanism is of special construction, bevel gear driven, totally enclosed in dust tight cases, designed to allow ease of removal for renewal of wearing parts and is operated by two 100 hp motors, connected in series. A Kennedy pinion housing with broad base is bolted direct to the foundation and contains two 40-inch pitch diameter pinions, 50-inch face with 16 double helical planned teeth. The mill spindles are steel forgings 16 inches diameter by 18 feet long, provided at both the roll and pinion ends with Mesta Universal couplings. The top mill roll and spindle are hydraulically balanced by constant pressure furnished by an independent accumulator and with special hydraulic pullback arrangement provided on both the top and bottom spindles for ease in changing mill rolls, the spindles being manipulated without the use of blocking or the crane, leaving the crane free for handling the rolls. The mill is connected to the engine by means of a Kennedy link type Universal coupling so that the drive from engine to mill rolls is free from back lash, eliminating wear and tear on all parts of the mill and permitting greater speed of reversal.

The manipulator is of the Hunt type, with side guards on each side of the mill and with special combination of turning fingers and actuating levers, of which there are three in number, mounted in conjunction with the side guard and rack beams on one side of the entering table for manipulating the ingot. The manipulator is so constructed that there are no working parts beneath the tables in the scale pit, all mechanism is located to one side of the table, opposite the operating side of the mill, the rack beams being located above the table beams, facilitating quick and easy removal for the renewal of wearing parts. It provides a simple direct means for manipulating the ingot with comparatively few moving parts and consequent light moving masses decreasing the inertia required for starting and stopping. It is operated by hydraulic power, permitting the ingot to be gripped by the side guards immediately it leaves the rolls, thereby promoting speed in rolling.

The 300-ton down cut crop shear is driven by a 75 hp ac motor and the clutch is equipped with a motor operated release. The continuous mill approach table is 88 feet long, containing 21 rollers, 14 inches in diameter with 4½x10-inch journals. The section of table next to the crop shear, 20 feet long, is hinged and counterbalanced at the shear end, being depressed with the shear as it cuts. A motor-driven screw actuated switch is provided at the entrance to the 21-inch continuous mill for deflecting the piece into the proper line of passes—this table is driven by a 50 hp motor.

The blooming mill is driven by a 42 inch and 66 inch by 60 inch horizontal twin tandem compound reversing engine, built by the United Engineering & Foundry Co., Pittsburgh. The engine is built with four bearings with center cranks on both sides, the diameter of the main shaft being 28 inches. The bed plates are unit castings including the bored guide barrel back to the point of attachment to the low pressure cylinders. The two beds being joined together at the end and along the bottom by a heavy tie section, the whole having full bearings on the foundation. Massive sole plates extend under the cylinders on each side of the engine and are firmly secured to the bed plate. The rear end of the low pressure cylinder and both ends of the high pressure cylinders are carried on breathing plates attached to the sole plates which permit the free expansion of both cylinders while maintaining their perfect alignment. The valves are tubular type, both the high pressure and low pressure valve stems are connected together in tandem in a straight line in a direct line with the valve gear, which is of the double eccentric Allen link type. The links are moved to their various positions by means of a steam cylinder, checked by a water jacketed oil cylinder, the valves of which are operated by a floating gear. This gear is inter-connected to the throttle valve so that it opens as the links move in either direction from their central position, so that the throttle opening and cut-off bar bear a fixed relation controlled by a single operating lever, designed to give the best economy and speed in operation. In the steam line between the steam receiver and the throttle valve is interposed an emergency hand operated butterfly valve with control lever in roller's pulpit and a Locke automatic overspeed shutoff valve also controlled from various push-button stations. The engine is operated under a steam pressure of 210 pounds, the greater part being furnished by the waste heat boilers at the open hearth. The exhaust from the engine is connected to a 108 inch Helander barometric condenser, furnished by the U. S. Cast Iron Pipe & Foundry Co., with an independent 12 inch by 30 inch by 20 inch Hall steam driven plate valve vacuum pump.

In the engine house are also located two 8 inch by 16 inch triplex geared Aldrich pumps, driven by a 400 hp ac Allis-Chalmers motor and a 30 inch by 10 foot accumulator furnished by the Pennsylvania Engineering Works in connection with the hydraulic system for the plant. In this building is also located an 8 inch by 11 inch by 14 inch Laidlaw horizontal duplex two-stage feather valve air compressor furnished by the Worthington Pump & Machinery Corporation, driven by a direct connected 186 hp Westinghouse, 220 volt synchronous motor, and the Bowser oiling system for the blooming mill engine and hydraulic pumps.

The Morgan continuous roughing mill comprises four stands with rolls 21 inches diameter by 48 inches long, the rolls of the mill being permanently set up with three lines of passes in them, the two outer pass lines to produce 4 inch by 4 inch billets and 8 inch by 2 inch slabs, the center line being a bullhead line capable of making slabs 3 inches thick from 6 inches to 12 inches in width.

To facilitate rolling slabs on this mill a set of 18 inch vertical edging rolls is installed between stands Nos. 2 and 3 to secure true and square edges on the slabs, which is of vital importance in their use in continuous heating furnaces to prevent their buckling when being pushed through the furnace.

The driving spindles of the mill are carried through the building partition wall into the motor house lean to which contains the bevel gear drive and the mill motor which is a 4,000 horse power Westinghouse wound rotor motor, taking 6,600 volt, 3 phase, 60 cycle current and having a full load speed of 93 rpm.

The 21 inch mill delivers to a skew connecting table 175 feet long, driven by a 40 hp motor—from this table material which has finished rolling on the 21 inch mill is transferred over a chain operated rail type transfer 160 feet long, driven by a 40 hp motor to a 180 foot long table, divided in two sections each of which is driven by a 40 hp motor and arranged to deliver material to the billet shear, or a future mill to be installed at the opposite end of the table paralleling the sheet bar mill.

The 18 inch continuous mill is a standard type Morgan combination sheet bar and billet mill, having six horizontal stands and two 16 inch vertical edging rolls.

Sheet bars and billets are sheared usually in 30 foot lengths on the Edwards flying shear, the shear table about 75 feet long being driven from the 18 inch mill with change gears in the connecting mechanism regulating the speed of delivery to correspond with the speed of the mill stand on which the section is finished.

The roll turning department is located in the motor house between the drives for the 18 inch and 21 inch mill, the equipment consisting of a 31 inch roll lathe with bed 18 feet long driven by a 15 hp motor for turning rolls for the 8 inch and 21 inch mills and a 42 inch lathe with a bed 27 feet 10 inches driven by a 30 hp motor for turning the blooming mill rolls. The lathes are direct motor driven, all gears are cut and located in an enclosed type of head stock and run in oil, and were furnished by the

A. Garrison Foundry Company. In this section of the motor house is also located the Bowser oiling system of filtering and delivering oil to the bearings of the 18 inch and 21 inch mill drives.

At the opposite end of the motor house, adjacent to the blooming mill engine room is located the sub-station containing two 1,500 kw motor generator sets supplied by the General Electric Company with space provision for a third. The sub-station receives 6,600 volt, 3 phase, 60 cycle current over a high tension line connected with the main power generating station at the blast furnace, and is converted by the motor generator set into 230 volt dc current for the requirements of all steel plant cranes, mill table drives, etc. In the sub-station are also located three 200 kva and four 750 kva self-cooled indoor type alternating current transformers, furnished by the Pittsburgh Transformer Company.

All small motors throughout the plant for cranes, mill table and auxiliary drives were furnished by the Westinghouse Electric & Manufacturing Co. and the control equipment by the Cutler-Hammer Manufacturing Company.

To supply the additional water requirements from the Ohio river, the intake and screening facilities at the existing pump house were greatly increased, the changing of the intakes and necessary dredging of the banks and river bed to allow for an unrestricted flow of water to the intake, was done by the Foundation Company. In the pump house the old vertical centrifugal pumps were removed, new suction and discharge piping was installed, connecting with two 18 inch horizontal single stage centrifugal pumps, direct connected to 700 hp, 6600 volt, 3 phase, 60 cycle, wound rotor induction motors, furnished by the Allis-Chalmers Company, and each having capacity of 16,000,000 gallons per day against 175 ft. head, there being four of these units installed at present in the pump house.

A 60 foot extension was added to the south end of the power house and two 7500 kw Curtiss steam turbine generating units, furnished by the General Electric Company, were installed in addition to the existing machine of the same capacity, one of which will be held as reserve, the other two furnishing high potential current for the steel plant and blast furnace and through its tie connection with the power station at Weirton tinplate plant, containing two 3000 kw machines, current is furnished for the operation of the river pumps and the mills at the strip steel plant. A Carrier air washer and humidifier, having a capacity of 29,000 cubic feet of washed air per minute is installed in connection with each turbine in the basement, supplying the cooling air required for the generators. This air is discharged behind a brick partition in the powerhouse basement from which it is vented to the outside through an adjustable shutter arrangement and in cold weather a portion of the warm air may be brought up through the powerhouse floor for heating the building. The turbines exhaust through 66 inch lines into two Elliott-Ehrhard barometric condensers, each equipped with two Elliott-Ehrhard steam air ejectors designed for 28 inch vacuum.

Two Alberger turbine driven centrifugal pumps each having a capacity of 5000 gallons per minute against a head of 140 ft. located on the floor of the pump pit over the storage reservoir, recirculate the water through a 24 inch cast iron line to the open hearth and mills, a 20 inch branch being taken off at the north end of the open hearth and a 20 inch and 18 inch line extending to a 30 foot diameter by 100 foot high stand-pipe located central to the mills. This standpipe furnishes additional reserve capacity and uniform head. It was furnished and erected by the Riter-Conley Company.

Condensing water for the blooming mill engine condenser is delivered through a 20 inch cast iron line from the pumping station in the power house, being recirculated by an Alberger centrifugal pump having a capacity of 7,000 gallons per minute, against a 65 ft. head, direct connected to a 150 hp Westinghouse ac, 220 volt motor.

The addition to the boiler plant of a 5-bay 100 foot extension to the boiler house in which are installed five 603 hp Stirling water tube boilers with power specialty superheaters, equipped with Westinghouse underfeed stokers, capable of burning coal to develop 200 per cent of the normal rating of the boilers continuously, each boiler being equipped with a Green radial flow, double inlet forced draft fan with a capacity of 23,000 cubic feet per minute against a 6½ inch static discharge pressure, and driven by direct connection to 50 hp 220 volt, ac Westinghouse motors.

A steel breeching, furnished by R. Munroe & Sons Manufacturing Corporation, connects the coal fired boilers with a 15 foot by 225 foot high reinforced concrete chimney with radial brick lining, built by the Rust Engineering Company.

Boiler feed water for the entire plant is furnished through a continuous hot process filtering and heating system, the water passing through three sand filters to a Cochrane feed water heater receiving exhaust steam from the turbine driven circulating pumps in the powerhouse, the turbine driven boiler feed pumps and other miscellaneous sources of supply. The heater is mounted on top of a sedimentation tank receiving the proper amount of chemical for treatment by means of a Cochrane chemical mixing tank, pumping set and proportioning device, water being delivered to the boilers by two of three Jeanesville centrifugal boiler feed pumps, installed with the filtration plant at the north end of the boiler house. A low head Allis-Chalmers centrifugal pump is provided for pumping water from the filtration plant to the open hearth boilers as previously described.

All pipe lines, with the exception of the underground cast iron bell and spigot lines, including steam, exhaust, boiler feed, blowoff, water supply lines above ground and all hydraulic piping was furnished and installed by B. Floersheim & Co., using the Crane Company American standard flanges, fittings and valves throughout.

The coal and ash handling equipment for the boiler house was furnished by the C. W. Hunt Company.

A machine shop of brick and steel construction has been provided, which includes the electric repair shop, small stores and winding room. The machine tools consist of one 60 inch Detrick and Harvey convertible open side planer, one 36 inch by 24 foot American lathe, two 24 inch by 16 foot American lathes, two 20 by 2 foot American lathes, one 5 foot Niles-Bement-Pond full universal radial drill, one 62 inch King vertical boring mill, two 3 foot American radial drill presses, two 25 inch Silver upright sensitive drills, one No. 3 Cincinnati milling machine, three 24 inch Cincinnati heavy duty back geared shapers, one 3 inch Acme bolt cutter, two 5 hp U. S. Electric Tool Company ball bearing floor grinders, one No. 10 Racine high speed saw, one Oster 2½ inch to 8 inch pipe machine, one No. 2 Oakley tool cutter and grinder and a 6 inch by 6 inch Peerless high speed power saw—all tools being provided with independent direct motor drives. A portable 330-ton hydraulic press furnished by the Hydraulic Press & Manufacturing Co., is also installed in the machine shop.

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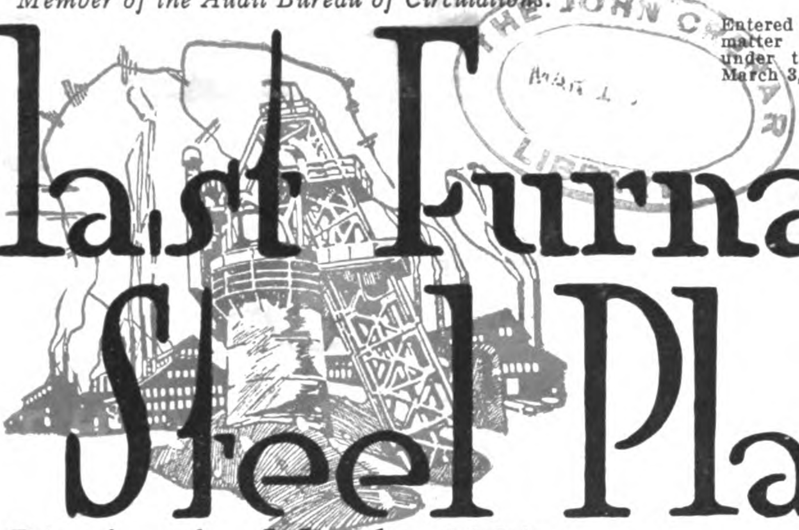
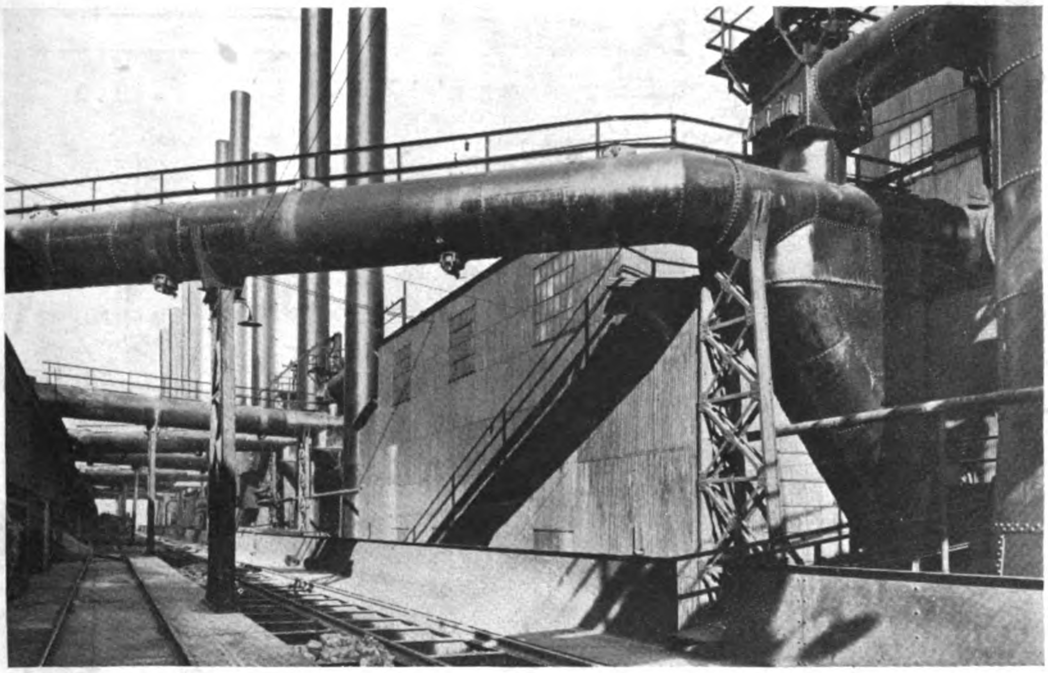


The Blast Furnace and Steel Plant

Pittsburgh, March, 1921.

MORGAN
OF WORCESTER
PRODUCER GAS MACHINES
COMPLETELY AUTOMATIC



This Picture represents the Gas Flues and Trackage between Open Hearth Building and Gas Houses at one of the leading Ohio Steel Plants where 35 Morgan Producer Gas Machines are in service.

MORGAN CONSTRUCTION CO.
WORCESTER, MASS. U.S.A.